An account of the operations carried out for accomplishing a ...

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AN

ACCOUNT OF THE OPERATIONS

CARRIED ON FOR ACCOMPLISHING

A TRIGONOMETRICAL SURVEY

OF

ENGLAND AND WALES,

CONTINUED FROM THE YEAR 1797,

TO THE END OF THE YEAR 1799.

BY CAPTAIN WILLIAM MUDGE,

OF THE ROYAL ARTILLERY, F. R. S.

VOL. II.

ILLUSTRATED WITH SEVEN COPPER PLATES.

FROM THE

PHILOSOPHICAL TRANSACTIONS.

LONDON:

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AND TO HIS ROYAL HIGHNESS THE PRINCE OF WALES,
CHARING CROSS.

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TRIGONOMETRICAL SURVEY, 1797—1799.

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PLATES.

N. B. The Numbers affixed to the above Plates have not been altered since Impressions were taken from them for the Philosophical Transactions.

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AN

ACCOUNT OF THE OPERATIONS

CARRIED ON FOR ACCOMPLISHING

A TRIGONOMETRICAL SURVEY.

By William Mudge.

Read before the ROYAL SOCIETY, *July* 3, 1800.

INTRODUCTION.

Having interspersed in the following Paper, with as much attention to brevity as the subject admits, every intelligence relating to the Trigonometrical Survey, I think it unnecessary to swell the bulk of the communication, by giving a long prefatory account of its progress since the year 1796.

The contents of the work now meeting the public eye, are important and numerous: I have divided it into sections. The first contains the calculations of the sides of the principal and secondary triangles extended over the country in 1797, 1798, and 1799; together with an account of the measurement of a new base line on Sedgemoor, and a short historical narrative of each year's operation. The second section contains the computed latitudes and longitudes of those places, on the western coast, intersected in 1795 and 1796, and also such others, since determined, as lie conveniently situated to the newly-observed meridians. This section also contains the directions of those meridians; one on Black Down, in Dorsetshire; another on Butterton Hill, in Devonshire; and another on St. Agnes Beacon,

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in Cornwall. Among the contents are likewise to be numbered the bearings, distances, &c. of the stations and intersected objects, from the parallels and meridians

The third and last section contains the triangles which have been carried over Essex, the western part of Kent, and portions of the counties joining the former, Suffolk and Hertfordshire. It is with satisfaction I am enabled to state, that Mr. GARDNER, the chief Draftsman, with his assistants, has almost completed the Survey of this extensive tract, which, no doubt, like the map of Kent, will be given to the public: the materials for these different surveys are ample, and will be found in this section, which concludes with the altitudes of the stations and mean refractions.

Before I had advanced far in my work, I entertained ideas of condensing all the *data* in my possession, and distributing them in it; but, when I found my paper would, in that case, be too large for the Philosophical Transactions, I desisted, contenting myself with presenting little more than a moiety: it is even now, of inconvenient magnitude, but I could not, with propriety, still farther abridge it, for I have, in several instances, rejected important matter. I shall, therefore, take an early opportunity of compiling a fourth account, in which will be given the latitudes and longitudes of those places, in Essex, Kent, &c. found in the last section.

It is right, I should observe that, knowing from experience, how liable surveyors are to mistake the names of places, and also, how utterly impracticable it is to detect errors, till the interiors of the great triangles have been *filled up*, I have been cautious to give only the distances of such objects as could not be easily mistaken. I do not mean to insinuate that, among

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the great number now published, instances may not be found of misnomers, or even wrong bearings; but I rely with great confidence on their general accuracy, and particularly on those constituting the surveys of Essex and the northern shore of the Thames, as the whole of them have been *verified* by Mr. GARDNER. Indeed this is to be understood as holding good throughout the last section, in which are 375 triangles. In our former accounts of this survey, we were particularly guarded in not intermixing their contents with distances determined from numerous doubtful intersections; and experience has hitherto not detected above three or four errors arising from wrong bearings or misnomers. Previously, indeed, to the compilation of them, a great part of the objects in Sussex, Hampshire, and the Isle of Wight, were verified by Mr. GARDNER, in process of an extensive survey, carried on by the order, and performed for the service, of the Board of Ordnance. This gentleman will also have it in his power to detect any errors, if such exist, in the names of places to the westward; as the Master General has been pleased to issue his directions for the survey of Devonshire, and as much of Somersetshire and Cornwall as will *square* the work.

I have mentioned, in the body of the account, that the President and Council of the Royal Society, were pleased to accede to the request made by the Honorable Board of Ordnance, to entrust to my care, the circular instrument used by the late Major General ROY, in his well known operation. It has already been found highly useful, and will shortly prove to be still more so, as one theodolite will be employed in carrying the above orders of Marquis CORNWALLIS into effect, while the other is used in carrying a meridional line through the country; an undertaking begun, and partly executed.

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Before I close this Introduction, I am to announce, that Mr. ISAAC DALBY, no longer able to endure the fatigues incident to the service, has retired from it; and it would be a matter of injustice, if I were not to acknowledge the extent of his services, his unremitted labour, and attention. But, whilst I lament the loss of a man so perfectly calculated to assist me in this arduous undertaking, I derive every consolation from a knowledge, founded on experience, of the talents and abilities of Mr. SIMON WOOLCOT, his successor.

SECTION FIRST.

1. *Particulars relating to the Operations of the Year* 1797.

The principal object proposed to be accomplished this year, was the determination of the directions of meridians at proper stations, in order to afford the necessary *data* for computing the latitudes and longitudes of places intersected in the surveys of 1795 and 1796.

From errors which are the result of computations made on the supposition of the earth's surface being a plane, it is expedient that new directions of meridians should be observed, when the operations are extended, in eastern or western directions, over spaces of sixty miles from fixed meridians. The distance from Dover to the Land's End being upwards of 300 miles, it becomes necessary, on this principle, that four directions of meridians should be observed; which, with that of Greenwich, amounts to five, dividing this space into six nearly equal parts.

Whatever be the stations farther to the westward, which offer

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themselves as fit places for these observations, Dunnose in the Isle of Wight presents itself as highly eligible, not only because it is removed the necessary distance from the meridian of Greenwich, but also because it commands a most extensive view of the western coast: therefore, as the direction of the meridian was observed on this station in 1793, (see Philosophical Transactions for 1795, p. 517.) it became necessary to fix on three places only.

In the selection of these stations, it was our wish to have found such as should lie nearly in the same parallel, each intermediate one being visible from those east and west of it; by which means, the differences of latitude between their respective parallels would be accurately determined.

When the party was at Dunnose, in the year 1793, a hill at a very considerable distance, in a direction very nearly west, was seen just rising out of the horizon. It then occurred to us that this spot would, at some future period, be a very proper one for a station whereon a new direction of the meridian might be observed. Experience, in the Survey of 1795, led us to believe this hill was actually Black Down in Dorsetshire; therefore it was determined that our operations should commence at that station, and the event verified the truth of our suppositions.

The party took the field early in April, as observations on the Pole Star, for the purpose in question, are made with superior advantage at this season of the year, because the star comes to its greatest elongations from the meridian at those times, when the sun produces little tremor in the air, by which means, the staff to which the Pole Star is referred, in good weather, is easily perceived.

As the high land in the vicinity of Teignmouth, in Devonshire,

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cuts off all view of the southern extremity of Dartmoor from Black Down, the necessary alternative was, the firing of lights on some remote station, communicating with Butterton. Rippin Tor was quickly discovered to be the most proper spot; and that eminence would, in every point of view, be a most eligible one for a new direction of the meridian, if the hills in the middle of the moor were not considerably higher. It was, therefore, chosen only with a view of being subservient to the purpose of finding the latitude of Butterton.

In making observations on the Pole Star, the same precautions were taken to ensure accuracy, as were observed at Dunnose and Beachy Head in the year 1793; (see Phil. Trans. for 1795, p. 460.) I shall, therefore, not enumerate them, but content myself with observing, that no pains were spared in this performance.

From Black Down, the party removed to Butterton; at which place but few observations were made, the weather being either tempestuous or hazy, during the greatest part of the time we were at that station: they were, however, made under favourable circumstances, in other respects, and are therefore likely to afford accurate results.

As in the case of Rippin Tor, wlth respect to Black Down, so Hensbarrow, in Cornwall, was selected as the spot for connecting St. Agnes Beacon with the station on Butterton; for these latter are not visible from each other, the high land about St. Austle, on the northern part of which is situated Hens or Hengist barrow, being higher and intermediate. The staff to which the lights and star were referred, was placed on a hill called Hemmerdon Ball, a secondary station in the series of 1795.

On the 1st of May, the party proceeded to St. Agnes Beacon; at

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which place the observations were completed on the 8th. The staff for connecting the observations made on the Pole Star with those made on the lights fired at Hensbarrow, was placed near Peranzabulo; which spot is laid down in the plan, Pl. XXVII.

After these directions of meridians were determined, we proceeded with the survey, and from St. Agnes Beacon repaired to Trevose Head, a promontory on the northern coast of Cornwall. The ascent from the sea to the station on this headland being very gradual and unobstructed, we took the opportunity of finding its altitude by means of the transit instrument. The levelling was begun on the 30th of May, and finished the following day; from which operation, it was found that the height of the station above low water-mark was 274,2 feet; which is, probably, within six inches of the truth. This base of altitude, will afford the means of computing the heights of the stations in the north of Devon, and also of verifying those in the western part of Cornwall. (See Phil. Trans. for 1797, p. 471.)

In giving an account of this and similar articles, it is my intention merely to set forth the order in which the different parts of the survey have been performed. It would be prolix, and perhaps, unnecessary, to assign the reasons for the choice of each station. In the present instance, however, it may not be improper to observe, that a station called Black Down, near Lydford, was selected for the purpose of carrying distances into the north of Devon, by means of the side formed by that station and Carraton Hill. The difficulty of running up the series of triangles from the west, (and it might have been also added, towards the north,) is mentioned in the account of 1797. A tract of country exists in Cornwall, possessing the same characteristic features with Dartmoor, and has thrown in our

way equal embarrassments. The station called Carraton Hill, is situated on its southern extremity, from which no part of the north of Cornwall can be seen: it, therefore, became expedient to erect a staff on the top of the rugged hill Brown Willy, (a spot not accessible to the instrument,) and afterwards to content ourselves with *surveying round it*. This resolution became the more necessary, as by means of it, the triangles in the west of Devon will be hereafter connected with those in the north of Cornwall, in a shorter and more direct way than from the sides in the more southern country. In order, therefore, to observe the staff erected on this station, the instrument was taken a second time to Bodmin Down. The station named Cadon Barrow, near Camelford, and those on St. Stephen's Down, near Launceston, were also visited; at which time it was judged expedient to discontinue the operations in Devonshire.

In proceeding along the southern coast, in the years 1795 and 1796, with a single chain of triangles, we acted in conformity with our instructions. It was, in many points of view, the most eligible mode of proceeding; and particularly in that which regarded an early determination of the latitudes and longitudes of the great head-lands in the channel, and also of the Scilly Isles.

When the operations above spoken of were completed, and those instructions carried into full execution, (ample materials being provided for ascertaining the situations of every remarkable point on the English side of the channel,) the want of a spot in the southern part of Cornwall, for the measurement of a base, was felt and regretted; we were, therefore, unwilling to introduce errors, if any should exist, from the sides in Cornwall, into the north of Devon: our operations were consequently discontinued.

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From Devonshire we proceeded to the eastward, for the purpose of carrying on a second series of triangles. These were necessarily intended to originate from the side which connects the station on Beacon Hill, near Amesbury, with that on Wingreen Hill, near Shaftesbury.

In the month of July, the observations were completed at the station on the Mendip Hills, after which the instrument was taken to Bradley Knoll; Dundry Beacon, near Bristol; Lansdown and Farley Down; the station on Lansdown being chosen rather for a secondary than a principal place of observation.

From Bradley Knoll, to which place the instrument was carried from Farley Down, we proceeded to Westbury Down, and from thence to Beacon Hill, near Amesbury; because it was necessary that a new point on the range near Marlborough, commonly named St. Ann's Hills, should be observed. The station formerly chosen at the eastern extremity of this range, and observed in 1794, (see Phil. Trans. 1795, p. 471.) was this year found to be useless, as the high land, on the same range, prevented it from being seen at Lansdown: two others were, therefore, selected to the westward of the former, and observed from Beacon Hill; one for the purpose of connecting with Lansdown, and a station near Symmond's Hall, in Gloucestershire; and the other with Inkpin Beacon. The particular circumstances of this range, both as to situation and height, have thrown great impediments in the way of the survey, and are the means of cutting off, in a considerable degree, the connection between the southern triangles and those which have been since carried on in the midland of the kingdom. From Amesbury the party proceeded to Inkpin Beacon, near Hungerford, where the operations terminated.

The stations chosen and observed this year, but not visited with the instrument, were Monymoor, near Penhow; the mountain Twymbawlin, near Newport; and Scilly Point, in Glamorganshire. These stations in South Wales will connect with three in Somersetshire, also selected this season; one on Bleak Down, which is situated on the western extremity of the Mendip range; a second on Brent Beacon; and a third on the Quantock Hills.

Subsequent to the operations on Salisbury Plain, enquiries had been often made after a spot on which a third base might be measured. Experience had almost convinced us that, if Sedgemoor were excepted, the southern part of England did not contain one of sufficient extent for a base of three miles. Aware, therefore, of the imperfect state in which our work must rest, without a fresh base, Mr. DALBY and myself passed over into South Wales, and examined the extensive level between the new Passage House and Cardigan. After, however, a very diligent search, we could not find any spot, four miles in length, sufficiently unobstructed. The advantages which the situation itself holds out, are so great, that we should not have scrupled to dispense with a desideratum, heretofore required, of the base being one continued line. So much, however, is this flat cut up with *rhynes* and ditches, that we were not able to find any point from which two right lines might be measured, and so inclined to each other as to afford, by means of an including angle, a third side of five miles in length: necessity, therefore, compelled us to think of measuring a base on Sedgemoor, which we immediately examined. That which relates to this situation, will be found in an ensuing article: it is now only necessary to observe, that we concluded the operations of 1797, after the practicability of measuring a base upon it had been decided in the affirmative.

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ART. II. *Angles taken in the Year* 1797.

At Black Down.

Between	° ′ ″	Mean.
Dunnose and Abbotsbury staff - - -	164 26 33,75 37	35,25
Rippin Tor and Abbotsbury staff - - -	3 8 51,75 52,75	52,5
Pilsden and Abbotsbury staff - - -	45 16 15 13	14, but 13 preferred.
Pole star and Abbotsbury staff, April 17, morning -	104 19 26,75	
18, morning -	104 19 19,25	
19, morning -	104 19 33	
19, afternoon -	98 42 47	
20, morning -	104 19 25,25	
20, afternoon -	98 42 35,5	

At Butterton.

Hemmerdon Ball and Rippin Tor - - -	121 17 7,25 8,5	7,75
Hemmerdon Ball and Hensbarrow - - -	1 52 2,75 6,25	4,5
Pole star and staff on Hemmerdon Ball, May 6, afternoon -	91 29 13,75	
7, morning -	97 4 14	
7, afternoon -	91 29 12	

On St. Agnes Beacon.

Hensbarrow and Trevose Head - - -	47 10 0,75	
Hensbarrow and Peranzabulo staff - - -	31 50 55,5 56,25	56, but 55,5 pref.
Pole star and Peranzabulo staff, May 20, afternoon -	44 0 45,75	
21, afternoon -	44 0 44,75	
22, morning -	38 26 1,5	
22, afternoon -	44 0 33,25	
23, morning -	38 26 9	

At Trevose Head.

St. Agnes Beacon and Hensbarrow - -	65 43 43,75 47 50	47

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Between	°	′	″	Mean
Hensbarrow and Bodmin Down	34	17	45 46	45.5
Bodmin Down and Cadon Barrow	42	33	43 46,5	rejected.
			51,75 52,75	52

At Hensbarrow.

	°	′	″	Mean
St. Agnes Beacon and Trevose Head	67	6	13,25 13,25	13,25
Bodmin Down and Trevose Head	77	20	17,75 19,25	18,5

At Bodmin Down.

	°	′	″	Mean
Hensbarrow and Trevose Head	68	21	57,25 59.5	58,25
Trevose Head and Cadon Barrow	71	55	26,75 27	27
Carraton Hill and staff on Brown Willy	52	3 4	59.5 1,25 4.5	1,75
Carraton Hill and picket on Brown Willy	51	36	11 11	11
Cadon Barrow and staff on Brown Willy	30	58	13 13	13
Cadon Barrow and picket on Brown Willy	31	26	0,25 1,25 3,25	1,75

On Cadon Barrow.

	°	′	″	Mean
Trevose Head and direction post on Bodmin Down	68	7	53.75 54 54,25 54.75	54,25
Direction post on Bodmin Down and staff on Brown Willy	41	12	37.5 39 41	39,25
Direction post on Bodmin Down and picket on Brown Willy	40	40	34 36,75	35,25
Tresparrot Down and staff on Brown Willy	100	20	52,25 55 57	54.75
Tresparrot Down and picket on Brown Willy	100	53	1 1	1

At St. Stephen's Down.

	°	′	″	Mean
Staff on Brown Willy and Warbstow	41	18	24,25 25.5	25

Between	°	′	″	Mean. ″
Warbstow Beacon and Brendon Moor	39	41	18,5	18,75
			18,75	
			19	
Brendon Moor and Broadbury Down	90	0	40,75	41
			41	
Broadbury Down and Black Down	45	34	36 0	
			41,75	42,25
			43	
Black Down and Carraton Hill	91	18	12,25	12,75
			13,5	
Carraton Hill and Kit Hill	37	1	56	
Black Down and Kit Hill	54	16	13	

At Maker.

Carraton Hill and Black Down	53	4	28	29,25
			30,5	

At Carraton Hill.

Black Down and Maker Heights	74	5	22,5	22,5
			22,75	
Trevose Head and Bodmin Down	77	20	17,75	18,5
			19,25	

At Black Down.

Maker Heights and Carraton Hill	52	50	7,75	9,75
			11,75	
Carraton Hill and St. Stephen's Down	39	44	37,25	39
			40,75	
St. Stephen's Down and Broadbury Down	66	49	57,5	58
			58,25	
Carraton Hill and Kit Hill	13	12	58	

On the Mendip Hills.

Dundon Beacon and Bleak Down	85	15	59,25	1,25
			59,75	
		16	1,5	
			4,5	
Bleak Down and Brent Knoll	29	11	35,75	39,25
			38	
			41,25	
			41,75	
Bleak Down and Dundry Beacon	33	39	30,5	30,5
			30,5	

Between	°	′	″	Mean.
Dundry Beacon and Lansdown	41	3	58,5	58,5
			58,75	
Lansdown and Farley Down	19	32	16,5	16,75
			17	
Farley Down and Westbury Down	38	55	17	17,5
			18,25	
Westbury Down and Bradley Knoll	37	47	57	58,5
			57,75	
			58,75	
			59	
		48	0,25	
Farley Down and Dundry Beacon	60	36	15	15,5
			15,75	
Farley Down and Bradley Knoll	76	43	14	19,75
			18,5	
			21	

At Dundry Beacon.

Tickenham Down and Grey Hill	37	44	2,25	3,75
		3	3	
			6,25	
Tickenham Down and Kingsweston	60	3	27,25	28,75
			30	
Kingsweston and Grey Hill	22	19	23,5	25,75
			27,75	
Bleak Down and Grey Hill	120	0	23	25
			24	
			28	
Lansdown and station on the Mendip Hills	83	34	16,25	18
			19,75	
Farley Down and Mendip Hills	69	52	21	22
			23	
Mendip and Bleak Down	54	34	24	25,5
			25,75	

At Lansdown.

Kingsweston and Dundry	36	38	29	

On Farley Down.

St. Ann's Hill and Westbury Down	51	44	10,75	11,75
			11	
			11,25	
			13,75	
Westbury Down and Bradley Knoll	37	5	30,75	32,5
			31	
			34	
			34,25	

Between	°	'	"	Mean.
Westbury Down and Mendip Hills - - -	77	21	51,75	53,75
			55,75	
Bradley Knoll and Mendip Hills - - -	40	16	23	23,5
			23,75	
Mendip Hills and Dundry Beacon - - -	49	31	15,25	rejected.
			21,5	
			23	23,5
			23,75	

On Bradley Knoll.

	°	'	"	Mean.
Mendip Hills and Westbury Down - - -	101	23	56,5	59
			57,75	
		24	0	
			1,75	
Westbury Down and Beacon Hill - - -	42	43	29,25	29,75
			30,5	
St. Ann's Hill and Westbury Down - - -	7	28	44	45
			45,25	
			46,5	
Westbury Down and Milk Hill - - -	10	12	49,5	51,5
			53,25	
Beacon Hill and Wingreen - - -	57	50	38,25	
Beacon Hill and Bull Barrow - - -	98	34	31	32,5
			33,5	
			34	
Wingreen and Bull Barrow - - -	40	43	51,25	52
			52,75	
Bull Barrow and Ash Beacon - - -	45	43	3,25	3,5
			3,75	
Ash Beacon and Mendip Hills - - -	71	34	54,75	55
			55,25	
Mendip Hills and Farley Down - - -	63	0	21,5 D	

At Bull Barrow.

	°	'	"	Mean.
Ash Beacon and Mintern - - -	51	26	41	42
			41,75	
			43	
Bradley Knoll and Wingreen - - -	42	55	32,75	

At Pilsden Hill.

	°	'	"	Mean.
Mintern and Ash Beacon - - -	35	2	59	1
		3	3,25	

At Mintern.

Between	°	′	″	Mean.
Pilsden and Ash Beacon	95	35	21,25 22,5	22″
Ash Beacon and Bull Barrow	94	14	22 24	23

On Westbury Down.

Beacon Hill and Bradley Knoll	114	12	18,25 18,5 18,75	18,5
Bradley Knoll and Mendip Hills	40	48	1 1,75 1,75	1,75
Mendip Hills and Farley Down	63	42	50,5 52	51,25
Farley Down and St. Ann's Hill	88	50	1 3 4½	2,75
St. Ann's Hill and Beacon Hill	52	26	42,25 43,25	42,75
Beacon Hill and Milk Hill	48	7	31 36	33,5

Beacon Hill (Amesbury.)

Bradley Knoll and Westbury Down	23	4	15	
Inkpin Down and Milk Hill	66	14	58	
Inkpin Down and St. Ann's Hill	70	51	57,5 57,75	57,75
Westbury Down and Milk Hill	51	11	9	
Westbury Down and St. Ann's Hill	46	34	6 9,25	7,75

On Inkpin Down.

White Horse Hill and Highclere	133	27	57,25 57,5	57,5
Highclere and Beacon Hill	106	16	52,25 54,25	53,25
Beacon Hill and Hewish	51	53	31,25 33,5 35	33,25

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ART. III. *Particulars relating to the Operations of the Year* 1798.

The object first attained this year, consisted in a trigonometrical survey of the counties adjacent to the northern and southern shores of the Thames.

In the last communication it will be seen, that the survey of Kent had been carried on from the sea-coast, till it reached the range which runs eastward from Wrotham through Hollingbourn, and there terminated. The country to the northward could not be surveyed, because the view from General ROY's station at Wrotham is almost entirely cut off, in that direction. In order, therefore, to obtain a base for the purpose, when the party arrived at Wrotham, a new station was chosen, to the eastward of the former one, and the distance between them accurately measured; by which means, together with the included angle at the old station, and the distance of it from Severndroog Tower, on Shooter's Hill, a new distance was found, which became a base for the survey proposed.

The chief draftsmen and surveyors belonging to the Drawing-room in the Tower, attended our operations in this county, and also those afterwards carried on in Essex. It was, indeed, for their immediate service, that we renewed the survey in this quarter, as the Master-General had given directions to prepare ample materials for completing the map which meets the public eye with this article.

The stations in Kent, besides that of Wrotham, were Gravesend, Gad's Hill, and the Isle of Sheppey; those in Essex were Hadleigh, South End, and Prittlewell. Observations made from these places afforded *data* for the proposed survey: after they were completed, the small circular instrument supplied the

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place of the great one, and was used, with good effect, in carrying on the subsequent operations in this quarter.

In our Paper published in the Philosophical Transactions for 1795, an observation is made, of the necessity then existing for the measurement of a base on Salisbury Plain, in consequence of resolutions taken to inclose Sedgemoor: an act for which purpose was passed a few years ago, and partly carried into execution in 1797. At this time, however, King's Sedgemoor was only set out into parochial allotments, as exhibited in Plate XXVIII. accompanying this Account. The ditches, represented by lines on this plan, were generally ten feet broad, and five feet deep; but the principal and secondary drains were much wider, the first being thirty, and the last twenty-five, feet in breadth. The subdivisions on the Moor, or the individual allotments of it, were not traced out in the Somerton quarter, at this time, the task being deferred till the latter part of the following year. The measurement, therefore, of this base, in an early part of the season, became necessary, because fewer obstacles were then expected to present themselves.

As it appeared that many instances would probably occur, in which a chain of 50 feet in length would be useful, if not absolutely necessary, one was provided by Mr. Ramsden, in the winter; its make and form being precisely similar to those of the larger chains, used in the measurement of our former bases. Such a chain did, indeed, prove highly serviceable in the subsequent operation; as the handles of the 100-feet chain would very often have had their places in ditches, or been so situated on their banks, as to leave imperfect means of correctly placing the register heads under the handles.

The apparatus for the measurement, consisting of the tressels

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belonging to the Royal Society, pickets, iron heads, and a new set of coffers, were sent to Somerton, after Mr. GARDNER had been furnished with the means of proceeding with the survey before spoken of.

The measurement was begun in July, and finished in August; in the course of which, very little interruption arose from any inclemency of weather. It is unnecessary to enter minutely into a description of the difficulties which arose from the frequent intervention of ditches; let it suffice to observe, that, possessed of the 50-feet chain, these were rendered less material than they would otherwise have been.

When we arrived at that point which ends with the 114th chain, an *offset* was taken, and 19 chains measured, in a direction perfectly parallel to that of the base, at the extremity of which we returned into the base itself, and continued the measurement. This interruption proceeded from an accidental and unforeseen circumstance; a great ditch having been excavated in a direction coincident with that of the base, while the measurement was going on at the upper end of it. This, however, cannot be the means of introducing any sensible inaccuracy; for, to proceed in this matter correctly, when it became necessary to take an offset, a silver wire was let fall from the register head, having a plummet, under the point of which a small dot was made, on a stake driven firmly into the ground. *The great theodolite* was then placed over the stake, *and the instrument accurately adjusted over the dot.* A diaphragm, whose aperture was $\frac{1}{2}$ an inch, was then put over the object-glass of the transit telescope, which was afterwards directed towards the staff at Lugshorn Corner, and then moved round, till it exactly made a right angle with the base. The telescope being sufficiently

depressed, a peg was driven into the ground, with its centre nearly under the cross wires; after which, a pin was moved on the surface of the peg, as directed by a person looking through the telescope, till it came to that point at which it bisected the angle formed by the cross wires. The measurement was then carried on, in this new direction, a space of 19 chains, at the end of which, the same operations were repeated, and the old direction pursued. It does not seem probable, that an error amounting to more than $\frac{1}{10}$ of an inch, can have resulted from this procedure.

King's Sedgemoor being sufficiently level, the base was measured horizontally; an advantageous circumstance; but, from the soft texture of the soil, the pickets could not be driven into the ground so firmly as to be without some small degree of motion, in case a person stood close to them. Therefore, those who attended the handles of the chains, either used long stools, or placed themselves so as to divide the pressure arising from the weights of their bodies equally on each side of the pickets. The disturbances to which the register-heads were liable, did not discover themselves till a mile of the base had been measured; and, although it became probable that small errors only had resulted from the want of those precautions we afterwards followed, yet we considered what we had done as erroneous, and recommenced the measurement, with the advantage of experience. At present, I shall content myself with observing, that due attention was paid to all necessary minutiæ in this measurement, and refer those who are desirous of being more particularly informed, to the Philosophical Transactions for 1795, as the mode of proceeding on the present occasion was perfectly similar to that on Hounslow Heath.

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After the conclusion of this operation, we proceeded to select such stations in the neighbourhood of the base, as might afford means of connecting it with the triangles carried on in the preceding year. The two chosen for this purpose, were Dundon Beacon, and a spot near the village of Moor Lynch; both nearer to their respective ends of the base than we wished to have found them; yet, as small rods of only an inch in diameter were placed on those stations, when they were observed from Dundon Beacon and Moor Lynch, and the same erected at the ends of the base, when they were observed from those stations, it becomes probable that very trifling errors resulted from this proceeding.

The station at Ash Beacon was visited subsequent to these just spoken of, and afterwards that on the Mendip Hills, for the purpose of taking the angle between Moor Lynch and Dundon Beacon. The operations of 1798 then terminated with a diligent search after some spot in Cornwall, for a base of only two or three miles in length: this search, however, was fruitless, as in fact we had reason to imagine it would prove to be; but we were not willing to relinquish the hope, that a piece of ground might be discovered proper for so confined a purpose. The contrary, however, being the case, the party returned to London in October.

ART. IV. *Angles taken in the Year* 1798.

At Wrotham. Station of 1787.

Between	° ′ ″	Mean.
New Station and staff on Severndroog Tower -	94 19 30	

Station of 1798.

Between	° ′ ″	Mean.
Severndroog Tower and Gravesend - -	62 54 36,5 38,5 39,5	38

At Gravesend.

Between	°	'	"	Mean.
Severndroog Tower and Wrotham	82	39	21	21
			21	
Severndroog Tower and Langdon Hill	95	53	56	59
			59,25	
		54	1,25	
Langdon Hill and Hadleigh	34	31	49,5	53
			52,5	
			54	
			57,5	
Halstow and Hadleigh	30	24	17	19
			19,75	
			20,5	
Halstow and Gad's Hill	31	38	19,75	21
			22,25	
Severndroog Tower and Hadleigh	130	25	50	50,75
			51,5	

Isle of Sheppey.

Between	°	'	"	Mean.
Gad's Hill and Halstow	18	18	1,5	3
			3	
			3,5	
Halstow and Hadleigh	31	28	23	24,25
			24,5	
			25	
Langdon Hill and Hadleigh	16	26	30	
Langdon Hill and Rayleigh	27	4	46	

At Halstow.

Between	°	'	"	Mean.
Gad's Hill and Gravesend	24	18	21,25	21,25
			21,25	
Gravesend and Hadleigh	107	49	5,25	5,25
			5,25	
Hadleigh and Sheppey	99	18	4	6
			7,5	
Gravesend and centre of Rayleigh Tower	111	20	14	
Sheppey and Rayleigh Tower	95	46	57	

At Hadleigh.

Between	°	'	"
Sheppey and South End	38	43	29
Sheppey and Halstow	49	13	33,5
Gravesend and Halstow	41	46	32
Langdon Hill and Gravesend	43	11	51

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Between	°	′	″	Mean.
Gravesend and Severndroog Tower - -	26	16	56,75 57,75	″ 57,25
Langdon Hill and Sheppey - - -	134	11	55	

At South End.

Sheppey and Hadleigh - - -	119	20	5	

At Langdon Hill.

Gravesend and Severndroog - - -	53	47	25	
Centre of Rayleigh Tower and Gravesend -	122	2	46	
Station on Rayleigh Tower and centre of the same Tower -	0	0	27	
Station on Rayleigh Tower and Danbury Spire -	43	18	2	
Severndroog Tower and Frierning - -	95	25	0	
Frierning Tower and Station on Rayleigh Tower -	88	44	19	
Frierning and Danbury Spire - - -	45	26	17	
Severndroog Tower and Brentwood Spire - -	66	26	39	

At Triptree Heath. 1st Station.

Tillingham Tower and Station on Rayleigh Tower -	68	28	58	
Tillingham and Danbury Spire - - -	100	28	21	
Station on Rayleigh Tower and Langdon Hill -	21	25	14	
Station on Rayleigh Tower and Frierning Tower -	47	8	50	

At Lugsborn Corner.

Greylock's Foss and Dundon Beacon - -	107	44	30,75 31,25	31
Greylock's Foss and Moor Lynch - -	15	51	58,5 59 59,75	59
Moor Lynch and Dundon Beacon - - -	93	52	33,75	

At Greylock's Foss.

Moor Lynch and Lugshorn Corner - - -	114	9	58,25 59,75	59
Lugshorn Corner and Dundon Beacon - - -	8	29 30	59,75 0,5	0
Dundon Beacon and Moor Lynch - - -	105	40	0 0,5	0,25

Near Moor Lynch Windmill.

Between	°	'	"	Mean.
Greylock's Foss and Dundon Beacon	59	58	12,5	
Greylock's Foss and Lugshorn Corner	51	58	2,25 4,25	3,25
Lugshorn Corner and Dundon Beacon	8	0	10 10,25	10,25
Dundon Beacon and Mendip Hills	54	38	50 50	50
Mendip Hills and Ash Beacon	54	3	20 23,5 23,75	22,5
Ash Beacon and Pilsden Hill	57	19	2,5 3,75 4,5	3,5
Dundon Beacon and Pilsden Hill	56	43	36,25 36,5 37,25	36,75
Pilsden and Quantock Hills	87	15	6 7	6,5
Quantock Hills and Brent Knoll	71	38	57,75 58,5 58,5	58,25
Brent Knoll and Bleak Down	46	1	32,75 35,25 39	35,75
Bleak Down and Mendip Hills	43	41	43,5 45 45,25 46,75	45,25
Brent Knoll and Mendip Hills	89	43	19,5 20,5 24	21,25

On Dundon Beacon.

	°	'	"	Mean.
Lugshorn Corner and Moor Lynch	78	7	14,75 14,5	14,5
Lugshorn Corner and Greylock's Foss	63	45	28,5 29,5	29
Greylock's Foss and Moor Lynch	108	1	51,25 53	52,25
Moor Lynch and Bleak Down	58	42	10 10,25	10,25
Moor Lynch and Mendip Hills	101	22	54,25 55	54,5

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At Ash Beacon.

Between.	°	′	″	Mean.
Moor Lynch and Mendip Hills	56	29	50 52,25 52,25	51,5
Mendip Hills and Bradley Knoll	50	8	45,25 45,75	45,5
Bradley Knoll and Bull Barrow	93	38	10,5 13 14	12,5
Bull Barrow and Pilsden	83	40	33,5 35,5	34,5
Mintern Hill and Pilsden	49	21	35,75 39,75 39,75	38,25
Pilsden and Quantock Hills	59	34	40,5 42,25	41,5
Quantock Hills and Mendip Hills	72	57	49,75	

On the Mendip Hills.

Between.	°	′	″	Mean.
Bradley Knoll and Ash Beacon	58	16	20 21,5 24,25	22
Ash Beacon and Moor Lynch	69	26	46,5 49 49,25	48,25
Dundon Beacon and Moor Lynch	23	58	16,5 17,75	17

ART. V. *Particulars relating to the Operations of the Year* 1799.

I have shewn in the preceding articles, that sufficient materials are now in my possession, for calculating the latitudes and longitudes of those places whose bearings and distances from given stations are found in the Account of 1797. I have also pointed out the direction which the survey has subsequently taken; and given a short account of the measurement of a new base in Somersetshire. The operations of 1799 now remain to be spoken of.

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In very early stages of the work, I had frequent opportunities of observing, that eminent advantages would accrue to the service, were the survey prosecuted on a more extensive scale. The consideration of a grand instrument being laid up in the apartments of the Royal Society, suggested the propriety of obtaining it; therefore, when my appointment to my present situation gave me the means of effecting former ideas, I lost no time in applying to the President and Council, for the loan of their large theodolite, the excellence of which had been incontestibly demonstrated by the late Major General Roy. The distinguished services which the Royal Society have rendered this branch of the public service, leave it almost unnecessary for me to observe how readily they granted my request. The instrument was, accordingly, put into the hands of Mr. Ramsden, early in the month of January, for the purpose of being examined, and also of having new microscopes fixed to it; the former ones being much inferior, in construction, to those attached to the instrument belonging to Government.

To carry on so extensive a survey as that which is now the subject of this Paper, much consideration is necessary. I have endeavoured to give it the best effect, both as to design, and celerity of execution. What degree of success has attended my endeavours, the public, in possession of this Paper, can readily determine. In the present stage of the survey, I have been sufficiently impressed with just ideas, as to the importance of the task, and responsibility of my situation. The difficulties which start up, in prosecuting a survey of this kind, become more numerous as it becomes more extensive. In the earliest part of it, when few objects only were in view, speedy execution followed the design; but, circumstances now require every

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exertion, as the triangles are branched out into several parts of the kingdom.

Were the length of a degree of the meridian, in these latitudes, accurately known, the most eligible method of carrying on the survey would be, that of working between any two determined parallels of latitude, till the space between them was completed. Yet this mode would manifestly be subject to some slight innovations, from the necessity of measuring bases in certain stages of the work: it would be right, however, to adopt the principle for general practice. Under this idea, it would have been proper to have commenced the operations of this year in Somersetshire, and to have carried on the triangles from the neighbourhood of the new base into the north of Devon.

It is mentioned in one of the former Accounts, that a zenith sector was formerly bespoken of Mr. RAMSDEN, by his Grace the Duke of RICHMOND, for the purpose of aiding the design of measuring the length of a degree of latitude in this country. The pressure of other business caused Mr. RAMSDEN to lay aside this instrument, after he had considerably advanced in its construction. The real necessity, however, for our being supplied with an instrument of this description being made known to him, he resolved to take it in hand again, and complete it. Relying on the strength of his assurances to this effect, I determined to relinquish the intention of proceeding to the westward; and resolved to commence this year's operations, with running up a series of triangles along the meridian of Blenheim. As it is probable my next communication will contain the result of this interesting part of the survey, I shall now confine myself to such particulars as relate to the subject under consideration.

In a former article, I have observed, that the chief Draftsman,

Mr. GARDNER, has been furnished with materials for surveying the northern shore of the Thames, and the north of Kent: these proved ample, as the map, thence compiled, will sufficiently demonstrate. As the Master-General issued directions, at this time, to survey Essex, and parts of the adjoining counties, in the same manner, and for the same purpose, as Kent has been, I was obliged to suspend, for a short time, my intention of proceeding with the measurement of a meridional degree, and to devise the best means for carrying his Lordship's instructions into execution.

For this purpose, therefore, before any stations were chosen in Essex, the county was very minutely examined; when it appeared, that insuperable difficulties would occur, if the survey were prosecuted with the large theodolite only. The range commencing at Havering Bower, and running to Gallywide Common, cuts off a regular communication between the stations subsequently chosen in the southern and northern parts of Essex. The difficulty resulting from this circumstance, was made still greater, from the want of success in our endeavours to find one spot on this range, proper for a station. The eastern part was, in some degree, found more favourable; but it was discovered that, even here, the small instrument must frequently be used as a substitute for the large one. Under these disadvantages, the survey commenced in March; the large theodolite being taken to a station on Hampstead Heath.

The base chosen for carrying on the distances towards the north, was that constituted by Severndroog Tower on Shooter's Hill and the new station on Hampstead Heath; which distance, although it has not, perhaps, been obtained so correctly as many others, yet is determined with sufficient accuracy for the matter

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in hand. When the observations were made on Severndroog Tower, in the year 1787, the angle between Hanger Hill Tower and the cross on the dome of St. Paul's was taken: this was now made use of, in order to get the angle between Hanger Hill Tower and Hampstead Heath; because the former station could not be discovered, on account of the wind blowing the thick and darkened atmosphere of London between the stations, when the instrument this year was carried to Shooter's Hill.

For the purpose of connecting the eastern and western triangles with each other, a station was chosen on Southweald Tower, accessible only to the small instrument. Brentwood Spire was also found to be conveniently situated for carrying on the distances: this will be readily perceived by the plan. Langdon Hill was also selected; which, with the former station at Gravesend, were to become the means of connecting the triangles. A station on Epping Forest was judged necessary; but no spot could be found fit for general purposes, the view towards the north being confined. One was, however, fixed on, called Highbeech, from which a high building near Berkhamstead was found to be visible, by means of which, the distances in the north of Essex could be verified, as the station on the top of it would connect with Bushy Heath, near Watford, and a point on the elevated range near Dunstable.

From Hampstead, the instrument and portable scaffold were carried to Langdon Hill, and from thence to Triptree Heath, near Malden; from whence the party repaired to Highbeech, leaving the remainder of the county to be surveyed with the small circular instrument; which seems to have been done with considerable accuracy.

After the necessary observations were made at Highbeech, I

proceeded to Shotover Hill, in Oxfordshire; and, before May elapsed, had reconnoitred the country. As the distance between Inkpin Hill and Highclere, appeared to be shorter than was necessary for a base on which the northern triangles were to rest, it became certain, that their sides would depend on the base on Hounslow Heath. The only means by which the series now proposed to be carried westwards, (for the double purpose of forwarding the survey, and also of finding a portion of the meridional arc,) could be properly connected with the triangles in the neighbourhood of Salisbury Plain, was the side just spoken of; for the high land in the vicinity of Calne, intercepted the view of the stations on the Marlborough range, from White Horse Hill. In order, however, to make a connection, although imperfect, an intermediate station was chosen on this high intercepting land.

When the ground about Nettlebed was formerly examined by us, it appeared difficult to carry on the triangles from Bagshot Heath towards the northward; because no spot could be found near the former, from which the Chiltern range could be seen. I now, therefore, departed from the usual practice of choosing stations on the ground, and selected Pen Church Tower; by means of which, I found a connection might be made between the triangles carried round the Chiltern range, from White Horse Hill and Nuffield, with those in Hertfordshire.

At Shotover Hill the party separated, each having its instrument. I shall close this article, without entering minutely into the reasons which operated with me for the choice of all the stations selected this year. I shall content myself with enumerating the names of the stations visited and observed, and mentioning that Shotover Hill and Cumner Hill, in Oxfordshire, were selected principally with a view of ascertaining the situations of the

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observatories at Oxford and Blenheim. The names of the stations were, Nuffield, White Horse Hill, and Scutchamfly, in Berkshire. Shotover Hill, Cumner Hill, Whiteham Hill, Crouch Hill, and Epwell Hill, all in Oxfordshire. Those in Gloucestershire were, Pen, Cleave, Broadway Beacon, and the Malvern Hills. The Lecky Hills, in Worcestershire. Corley and Nuneaton, in Warwickshire. Bardon Hill, Naseby Field and Barrow Hill, in Leicestershire. Arbury Hill, and Souldrop, in Northamptonshire. Quainton, Brill, Wendover, and Bow Brickhill, in Buckinghamshire. Woburn Park, and Lidlington, in Bedfordshire. Kinsworth, Lillyhoe, Berkhamstead, Tharfield, and Bushy Heath, in Hertfordshire. From the last mentioned station, the party returned to London, in October.

Art. vi. *Angles taken in the Year* 1799.

On Hampstead Heath.

Between	°	′	″	Mean.
Hanger Hill Tower and Stanmore - -	50	52	15,75 17	16″,25
Highbeech and Shooter's Hill - -	70	6	35,5 34,5	35
Highbeech and St. Paul's, London - -	83	1	17,25 22,75	20
Severndroog Tower on Shooter's Hill, and Hanger Hill Tower	117	22	13 11	12

At Langdon Hill.

Gravesend and Severndroog Tower - -	53	47	25
Centre of Rayleigh Steeple and Gravesend - -	122	2	46
Station on Rayleigh Steeple and centre of the same -	0	0	27
Station on Rayleigh Steeple and Danbury Spire -	43	18	2
Severndroog Tower and Frierning Steeple - -	95	25	0
Frierning Steeple and Station on Rayleigh Steeple -	88	14	19
Frierning Steeple and Danbury Spire - -	45	26	17
Severndroog Tower and Brentwood Spire - -	66	26	39

At Triptree Heath.

Between	°	′	″	Mean. ″
Tillingham Steeple and Station on Rayleigh Steeple	68	28	58	
Tillingham Steeple and Danbury Spire	100	28	21	
Station on Rayleigh Tower and Langdon Hill	21	25	14	
Station on Rayleigh Tower and Frierning Steeple	47	8	50	

At Highbeech.

	°	′	″	Mean.
Severndroog Tower and Brentwood Spire	71	16	43 45	44
Severndroog Tower and Southweald	44	34	27 29	28
Severndroog Tower and Hampstead	58	28	18 18	18
Cross on the Dome of St. Paul's and Hampstead	83	1	11	
Berkhamstead Gazebo and Hampstead	138	29 30	57 0	58,5

At Shotover Hill.

	°	′	″	Mean.
Nuffield and White Horse Hill	81	53	27,75 29,75	28,75
Scutchamfly Barrow and White Horse Hill	26	8	7,75 7,75 8,25	8
White Horse Hill and Whiteham Hill	48	5	31,25 32,75 33,75	32,75
Wendover and Scutchamfly Barrow	117	30	55 57,25	56

On Whiteham Hill.

	°	′	″	Mean.
Shotover Hill and White Horse Hill	114	54	34,75 34,75	34,75
Shotover Hill and Cumner Hill	55	52	34,5 35,5	35
Staff over the Quadrant at Blenheim and White Horse Hill	131	25	34,5 38,5	36,5

On Cumner Hill.

	°	′	″	Mean.
Whiteham Hill and Shotover Hill	99	29	47 49,5	48,5
Shotover Hill and Atlas on the Top of the Observatory at Oxford	29	23	34 34	[illegible]

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On White Horse Hill.

Between	°	′	″	Mean.
Nuffield and Shotover Hill	35	34	22,25 23.75	23,25
Nuffield and Brill	38	48	11,5 15,25	13,25
Scutchamfly Barrow and Shotover Hill	111	47	50	
Whiteham Hill and Staff on Blenheim Observatory	10	30	43.5 43.5	43.5
Brill and Stow on the Wold	64	45	42,75 44.75	43.75
Station near Calne and Inkpin	67	10	28,5 32,5	30,5
Highclere and Inkpin	12	4	11,25 11,5	11,5
Highclere and Nuffield	63	7	53,25 53.5	53,25

At Nuffield.

Bagshot Heath and Highclere	78	17	16,5 17.75 18,75 19.75	18,25
Highclere and White Horse Hill	53	33	49.5 49.75	49,5
White Horse Hill and Shotover Hill	62	32	3.5 4.5 6,5 7	5.25
White Horse Hill and Brill	86	4	15,75 16 17	16,25

On Scutchamfly Barrow.

White Horse Hill and Shotover Hill	111	47	50	
Shotover Hill and Wendover	34	26	50 50,75 52,75 54.5	52

At Stow on the Wold.

Cleave and Broadway Beacon	54	44	54.5 54.5 57 57	55.75

Between	°	′	″	Mean.
Broadway Beacon and Epwell - - -	72	38	48,5	″ 49,5
			49	
			50,5	
Epwell and Brill - - - -	60	56	6	6,25
			6,5	
White Horse Hill and Cleave - -	109	40	36,25	37
			36,75	
			37	
			37,75	

At Broadway Beacon.

Epwell and Stow - - -	69	10	30,75	31,75
			31,5	
			32,75	
Stow and Cleave - - -	78	53	6	7,75
			8	
			9,5	
Cleave and Malvern Hills - - -	60	28	12,5	16
			17,75	
			18	
Malvern and Lecky Hills - - -	53	53	19½	19,75
			20	

At Epwell.

Stow and Broadway Beacon - - -	38	10	43,25	44
			43,5	
			44	
			44,25	
			44,5	
Stow and Brill - - - -	86	29	13	13,5
			13,5	
			13,75	
Brill and Arbury Hill - - -	85	0	16,5	18,5
			20,5	
Arbury Hill and Corley - - -	54	55	17, 5	18,75
			19	
			20,25	

At Corley.

Bardon Hill and Nuneaton Common - -	49	54	50,75	51,75
			53	
Nuneaton and Arbury Hill - - -	110	20	52	52,75
			52,5	
			52,75	
			53	

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Between	°	'	"	Mean "
Arbury Hill and Epwell - - -	35	17	34,75	36,75
			35,75	
			36,25	
			36,75	
			38	
			39,25	
Epwell and Broadway Beacon - - -	28	2	46,75	49,75
			50	
			53	
Nuneaton and Lecky Hills - - - -	133	25	11,5	11,5
			11,5	
Nuneaton and Station near Birmingham - -	49	54	50,75	52
			53	

At Arbury Hill.

Quainton and Brill - - -	16	12	37,25	40
			37,5	
			40,5	
			42,5	
			42,75	
Brill and Epwell - - - -	60	35	43	45,5
			43,25	
			44,5	
			45	
			46,5	
			48,5	
			48,5	

Near Brill on the Hill.

White Horse Hill and Stow - - -	50	14	44	44,5
			44,5	
			44,75	
Nuffield and White Horse Hill - -	55	7	33	33,5
			34	
Stow and Epwell - - - -	32	34	42,5	43
			43,5	
			43	
			43,25	
Epwell and Arbury Hill - - -	34	23	58,5	58,5
			58,75	
Arbury Hill and Bow Brickhill - - -	68	20	7,75	
Bow Brickhill and Wendover - - -	57	25	1	1,5
			2	
Wendover and Shotover Hill - - -	108	5	22	22,75
			23,5	
Quainton and Wendover - - -	51	34	33,25	33
			32,75	

Near Wendover.

Scutchamfly Barrow and Shotover Hill - -	28	2	12,75	

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Between	°	′	″	Mean.
Brill and Quainton	33	26	48 48 48,25	48″
Brill and Bow Brickhill	80	11	8,25 10,25	9·25
Brill and Shotover Hill	23	23	56,25 58,75	57·5
Bow Brickhill and Stanmore	102	22	29	
Pen Tower and Stanmore	38	13	16,25 19,75	18
Near Quainton.				
Bow Brickhill and Wendover	94	23	49,25 51,25	50,25
Wendover and Brill	94	58	36 38	37
At Bow Brickhill.				
Brill and Arbury Hill	68	22	55·5 55·75 57·5 58,75	56,75
Brill and Wendover	42	23	50,5 51	50,75
Wendover and Kinsworth	46	18	4,25 5·75 9,25 14	8,25
Kinsworth and Quainton	85	9	51,75 53,75	52,75
Kinsworth and Lillyhoe	42	10	33,25 38,5 39	36,75
Kinsworth and Lidlington	80	39	37,25	
Trusler Hill and Lillyhoe	14	54	38,75 43·5 45·5	42,5
Trusler Hill and Arbury Hill	45	49	41,75 44	43
At Kinsworth.				
Brill and Bow Brickhill	62	55	35,25 38,5 39 42	38,75
Quainton and Bow Brickhill	52	17	56,25 57,25 57	56,75

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Between	°	'	"	Mean.
Bow Brickhill and Lillyhoe - - -	82	50	26	30,5
			30	
			35	
Lillyhoe and Tharfield Tower - -	12	12	39,75	40,75
			42	
Tharfield and Station on Gazebo at Berkhamstead -	50	2	55,5	53,25
			56	
		3	0,5	
			1	
Stanmore and Berkhamstead - -	41	15	56,5	57,25
			57,75	
Bow Brickhill and Stanmore - - -	173	37	43	44
			45	

Near Lillyhoe.

Bow Brickhill and Kinsworth - -	54	58	52,5	53
			52,5	
			52,5	
			53,75	
Lidlington and Bow Brickhill - - -	23	59	30	31
			32	
Bow Brickhill and Trusler Hill - -	5	52	11,5	
Station on the Ground near Tharfield Tower and Kinsworth	166	4	44,5	46,25
			48	

At Lidlington.

Kinsworth and Bow Brickhill - - -	68	16	19	22,25
			22,75	
			25,25	

At Crouch Hill.

Brill and Epwell - - - -	145	23	25,75	26,25
			27	

At Stanmore.

Wendover and Kinsworth - - -	37	41	39,25	41
			43	
Pen Tower and Wendover - - -	23	4	47,5	48,5
			47,5	
			47,75	
			49,25	
			49,25	
Bagshot and Pen Tower - - -	49	32	29,5	
Bagshot Heath and Hanger Hill Tower - -	59	55	54,25	54
			53,75	

Between	° ′ ″	Mean.
Hampstead Heath and Hanger Hill Tower - -	45 25 51 51,5 51,5 52,75	51,75
On Busby Heath.		
Wendover and Kinsworth - - -	38 22 5 8,5	6,75
On Bagshot Heath. Station of 1794.		
Highclere and Nuffield - - -	55 32 25,5 25,75 26,75	26
Nuffield and Pen Tower - - -	48 47 11 12,75 12,75	12,5
Pen Tower and St. Ann's Hill - - -	70 30 37,25 39 40	39,25

ART. 7. *Situations of the Stations.*

Trevose Head. The station on this point of land, which is about four miles from Padstow, in Cornwall, is situated on the southern part of it, and is about forty feet from the declivity. The ground seems a little higher than any other part of the Head.

Cadon Barrow. The station is on the centre of the Barrow; which is a very remarkable one, and well known about the country. It is about two miles from Tintagel, being in a field lying south of the road leading from that town to Camelford.

Brown Willy. The staff is erected on the highest part of this mountain, which is about nine miles southward of Camelford.

St. Stephen's Down. The station is about 150 feet from the eastern part of the building erected on this Down. It lies south-west from the corner of it, and about twenty feet from the road.

Mendip. The station is in a field on the top of the down, being about two miles north of *Shepton Mallet.* The field is next to the road leading from that place to Bristol, and lies west of it: it is also north of the road which goes from Wells to Frome.

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This road crosses the former at right angles. The station is 20 feet north of the southern hedge, and about 200 from the eastern one. The ground round the station is rather higher than any other part of the field.

Dundry. The station is on the down, close to, but west of, the town so called. The down is full of holes and pits, from which stones have been taken for the purposes of building. The station, however, may easily be found, as it is situated on a rising which has the appearance of having been a barrow.

Lansdown. This place is well known, and near Bath. The station is on the highest part of the broken ground called CROMWELL's *Camp,* which is near Mr. GRANVILLE's monument.

Farley Down. The station on this Down is 5 feet north of the stone wall, and about 150 feet eastward of the plantation.

Bradley Knoll. This is a remarkable hill, very near Maiden Bradley. The highest part of the hill is towards the west, on which there is a small ring, exhibiting an appearance of a ruined plantation. The station is a few feet to the northward of this ring.

Westbury Down. There are no objects on this Down, of any kind; therefore, the station cannot be found from measurements. It is, however, just above the *White horse* cut out in the side of the hill.

Ash Beacon. This eminence is about four miles north of Sherborne: on the top of it there is a small plantation, round which is a circular wall. The station is 85 feet east of it.

Dundon Beacon. This is an insulated hill, at the eastern extremity of King's Sedgemoor; upon it are the remains of a barrow, probably the site of the ancient beacon. The station is about 4 feet eastward of the small cavity in the centre of it.

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Lugsborn Corner, the eastern extremity of King's Sedgemoor. There is a small rivulet, which separates the moor from the cultivated ground on the Somerton side, and, close to a particular part of it, is a passage called *Somerton Gate*. About a quarter of a mile eastward of this entrance, and in the second field, north of the stream, is the station called *Lugsborn Corner*, one of the ends of the base. The spot is 5 feet from the ditch, and 19 from the gateway. There were but three fields in this part of the moor, at the time the base was measured.

Greylock's Foss. This is towards the western extremity of the moor: a causeway leads from *Middlezoy* to *Greinton*, over it. In the second field from the bridge, near the latter, is the other extremity of the base. The station is about 10 feet from the ditch, running parallel to the Foss, and is in the angle formed by the ditch contiguous to the road and the second ditch north of the drain.

Nuffield. The station is in the field opposite to the church: it is in the south-west corner of it, 14 feet from the *stile*, and 10 feet from the hedge.

Scutchamfly. A very remarkable Barrow, on the Berkshire downs, situated near Little Hendred. The station is on the south-west part of it, and can easily be found.

White Horse Hill. This is a well known eminence in Berkshire. The station is on the eastern side of the Saxon work, and on the top of the small parapet surrounding the ditch.

Shotover Hill, near Oxford. The station is 150 feet from the hedge eastward of it, and 60 feet from that southward of it; but, when the traces of our former operations are obliterated, it will be difficult to recover this station.

Stow on the Wold. The station bearing this name, is in a

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field 2 miles eastward of the town: it lies on the north side of the road leading from Stow to Burford, and may be easily distinguished, being that particular field which affords the most commanding view. The station is 32 feet west of the corner of the hedge which forms a right angle with another abruptly running out: it is also 279 feet from the ridge which divides the field.

Broadway Beacon. This is a very high and remarkable spot, near the village of Broadway, in Gloucestershire. The station is about 20 feet south-east of the foundation of a building proposed to be erected by the Earl of COVENTRY.

Corley, a village in Warwickshire. The station is in the second field eastward of the church, being 180 feet from the eastern hedge, and 230 feet from the stile in the corner of it.

Epwell, a village in Oxfordshire. The station is on the apex of the hill, and may easily be found, by measuring 17 feet from the stile, and 14 feet from the hedge which runs across the hill. N. B. The station is west of the hedge.

Brill on the Hill, Buckinghamshire. The station is on *Muzzle Hill*, near the town. There is but one field on this hill: it is on the highest part of it. The station is situated in the centre of the field, and in the middle of a rising, once the site of a windmill.

Arbury Hill. This hill is still surrounded with the remains of an ancient fortification. The station is on the north-west corner of it, and near the brow, but cannot be easily found, from the want of proper objects to which measurements may be made.

Wendover, Buckinghamshire. The station is on the down south of the town, and contiguous to the village of Ellesborough, A road from Wendover, to Sir JOHN RUSSELL's seat, Checquers, runs over the down: but, as there are no marks on it, its pre-

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cise situation cannot be easily pointed out by measurement. It may, however, be observed, that it is 14 feet southwards, from the decayed parapet on the top of the hill.

Quainton, Buckinghamshire. The station is on the high ground, north of this town. It cannot very easily be found, because the hill is destitute of objects; yet it may, probably, be discovered, by looking for it on the *green ridge* which divides the land: it is in the middle of that boundary, and about 200 feet westward of the pathway.

Kinsworth, a village near Dunstable. The station is on the summit of a hill, about half a mile north of the village. A hedge runs across the hill, from which the station is 40 feet north-west: it is likewise *close* to the road.

Lillyboe, Hertfordshire. The station is on a commanding eminence, having the *Icknield way* at the foot of it. There are no objects on this hill, therefore the precise situation cannot be pointed out by means of measurement: it is towards the north-west corner of the hill.

Stanmore. This station is on the southern extremity of the range above the town: it is near the trees, and a little to the westward of the broken ground.

Busby Heath, near Stanmore, The station cannot be easily found: it is about 1000 feet from the road, but there are no objects near enough to determine it by measurement.

Wrotham. This station is $205\frac{1}{2}$ feet north-east of the old station: it may be easily found, with the assistance of a theodolite, Severndroog Tower making an angle of 94° 19′ with the new station.

Gravesend. The station is on Windmill Hill, and on the western side of it: it is about 50 feet south of the stile, and near the brow.

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Gad's Hill, Kent. The station is very easily found, being in the middle of the *tumulus.*

Sheppey, Isle of. The station is on the bare hill, westward of, and contiguous to, the high range: it cannot be found through means of measurement.

Hampstead. The station is on the heath, but cannot easily be found, on account of the rugged and broken ground which surrounds it: it is situated 40 feet from the road, and among the sand holes.

Langdon Hill, Essex. The station is in the middle of the field on the top of this hill: it is about 400 feet from either of the stiles.

Hadleigh. The station is on a remarkable hill, in shape very like a barrow, and is about a mile south-west of the town.

Southend. The station is in the second field westward from the terrace: it cannot be easily found.

Interior Stations.

Hope's Nose, the north projecting point of Torbay. The only spot fit for a station in this part is the one chosen: it can easily be found, for it is the high and bare rising, just above the Nose.

Ball's Obelisk. This object is on the eastern part of Great Haldon, in Devonshire. The station can be easily found, for it is close to the gate of the inclosure, and on the only spot not covered with heath.

Evercrutch, in Somersetshire. The hill on which the station is, commands an extensive view, and is not far from the town of Evercrutch. Bruton is also near it. The station is in the middle of the flat place on the top of the hill.

Crouch Hill, near Banbury, in Oxfordshire. The hill is well

known, and the station easily found; for the apex of the hill appears as if it were truncated, and in the middle of the smooth part is the station.

Cumner Hill, near Oxford. The station is about 130 feet westward from the centre of the clump of trees.

Whiteham Hill, Oxfordshire. There are a few trees contiguous to the station, which bear eastward from it, and are about 80 feet distant. The station is on the highest and smoothest part of the hill.

Lidlington, a village near Ampthill in Bedfordshire. This station can easily be found, for a tumulus, whose centre is the station, has been erected, to render it conspicuous.

Trusler Hill, in Woburn Park. The station is on a tumulus likewise; and can be found without any difficulty.

Stations in Essex, Suffolk, and Hertfordshire.

Prittlewell Steeple.

Rayleigh Steeple. The station is in the north-east corner, 20 inches from the north parapet, and 4 feet from the eastern one.

Danbury Steeple. The instrument was placed in the four angles of the Steeple, as circumstances rendered it necessary. The points are readily found, as there is scarcely room in the corners to place an instrument. Stations were also selected on the following Steeples, &c.

Canewden Steeple.	West Mersea St.	Little Bentley St.
Frierning St.	Colchester, St. Mary's Staircase.	Woodbridge St.
Tillingham St.	Tattingstone St.	Butely St.
Thorp St.	Rushmere St.	Otley St.
Stoke St.	Great Tey St.	Henley St.
Dover Court St.	St. Osyth Priory, Flagstaff.	Falkenham St.
Peldon St.	Shoebury Ness, Staff.	Copdock St.

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Naughton St.
Lavenham St.
Bulmer St.
Glemsford St.
Toppesfield St.
Twinestead St.
Southweald St.
Pleshley St.
High Easter St.
HatfieldBroad Oak St.

Beauchamp Roding St.
Hornchurch St.
Naseing St.
Henham on the Mount St.
Thorley St.
Albury St.
Elmdon St.
Rickling St.
Thaxted St.
Balsham St.

Westham St.
Barking, Staircase.
Berkhampstead, Gazebo.
Gallywood Common.
Purfleet Cliff.
Babraham Mount.
Epping Mill, Base.
Brentwood Spire, surveyed round.

Stations in Kent.

Frant Steeple. Station of 1787.
Botley Hill. Do.
Chiddingstone St.
Mount Sion.
East Peckham St.
Tudely St.

Seal Chart.
Tunbridge St.
Oxford Mount.
Silverden Farm.
Well Hill.
Crayford St.

Ash St.
North Fleet St.
Stockbury St.
Hernhill St.

The stations chosen for the survey of Essex, and parts of the adjoining counties, as also for completing the survey of Kent, are mostly towers, as may be seen from the above. When the tops of the towers have been smooth and even, the stations were always in the centres of them; but, when they were covered with roofs, or had spires upon them, stations were chosen in the most convenient places, and staffs always erected. I have omitted giving the measurements by which the stations may be exactly found, Rayleigh and Prittlewell excepted, in order to avoid swelling this article to an inconvenient length.

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Art. viii. *Particulars relating to the Base on King's Sedgemoor, and the Reduction of that Base.* Plate XXVIII.

Comparisons of the Chains.

As the chains, after the measurement on Salisbury Plain, were oiled, and laid up in the Tower, no apprehensions were entertained that either of them was elongated by the rusting of the joints. It was, however, our wish to have compared them with each other, previous to the commencement of this operation, and attempts were made, but rendered unsatisfactory, from the want of sufficient firmness in the soil. It was not till we arrived at the 70th chain, that a good opportunity presented itself: the measuring chain A, was then compared with the standard B, and found to be thirteen divisions of the micrometer head, attached to the brass scale, in excess. In these trials, the temperature remained constant; the mercury in Fahrenheit's thermometer being at $66\frac{1}{2}°$.

The 50-feet chain, spoken of in a former article, came from the hands of Mr. Ramsden without being very accurately measured; therefore it now became proper to ascertain its length, by means of the standard chain. This was accordingly done at the present time; when B was found to exceed twice the length of the 50-feet chain, by 14 divisions of the micrometer screw; the thermometer, at the time of trial, standing at $69\frac{1}{2}°$.

At the conclusion of the measurement, the chains were again compared, when the working chain A, was found to exceed the standard, $17\frac{1}{4}$ divisions on the micrometer head: this was after 273 chains were measured. Now, when 70 chains only had been measured, the difference between A and B was 13 of those

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divisions; consequently $17\frac{1}{4} - 13, = 4\frac{1}{4}$ divisions, was the wear of B, in measuring 203 chains. Therefore, the whole wear is found by this proportion, *viz.* 203 : $4\frac{1}{4}$ :: 273 : 5,223 divisions, $= \frac{2}{100}$ of an inch; which very inconsiderable quantity, like the wear on Salisbury Plain, no doubt, arose from the pivots and pivot holes of the joints being polished by continual use. This supposition seems just; as the wear of the chain, after the measurement on Hounslow Heath, was found to be much greater.

The length of the chain A, as well as that of the standard B, was accurately ascertained by Mr. RAMSDEN, in the year 1793, as particularly shewn in the Philosophical Transactions for 1795. In the temperature of 54°, A was found to exceed 100 feet, $\frac{11435}{100000}$ of an inch; therefore, adding the wear which took place on Salisbury Plain, *viz.* $\frac{1}{260}$ part of an inch, we get the length of A at the commencement of the measurement on Sedgemoor = 100,01009 feet.

From repeated trials, as before observed, the standard B was found to exceed the length of twice that of the new fifty-feet chain, 14 divisions of the micrometer head; and, *after* the measurement, the same chain fell short of A, $17\frac{1}{4}$ of those divisions: hence, A exceeds twice the length of the 50-feet chain, $31\frac{1}{4}$ divisions. Therefore the length of the short chain, in the temperature of 54°, may be taken at 50,00075 feet.

Art. ix. *Table of the Measurement of the Base of Verification on King's Sedgemoor.*

Days.	Spaces measured. Yards.	Mean temp. by 15 therm.	Days.	Spaces measured. Yards	Mean temp. by 15 therm.	Days.	Spaces measured. Yards	Mean temp. by 15 therm
July	100	69,7		3200	79,27	6	6300	92,26
	200	65,56		3300	79,96		6400	86,73
11	300	62,73	25	3400	62,06		6500	68,30
	400	67,40		3500	65,90	7	6600	82,06
	500	64,10	26	3600	67,63		6700	91,06
12	600	65,30		3700	65,83		6800	89,76
	700	73,40	27	3800	67,72		6900	93,43
	800	69,36		3900	75,53	8	7000	75,94
	900	68,06		4000	71,40		7100	81,57
13	1000	66,05		4100	71,23		7200	81,93
	1100	70,30		4200	67,14		7300	79,36
	1200	69,33	31	4300	66,56		7400	68,20
	1300	62,83	Aug. 1	4400	71,16	9	7500	78,18
14	1400	63,93	2	4500	64,60		7600	76,50
	1500	61,40		4600	65,16		7700	71,26
	1600	57,03		4700	68,16		7800	72,13
16	1700	66,36		4800	70,16		7900	70,8
	1800	65,80		4900	76,23	13	8000	71,5
	1900	71,03		5000	70,66		8100	8,4
17	2000	75,70		5100	64,23		8200	84,53
	2100	80,43	3	5200	64,46		8300	76,13
	2200	77,53		5300	63,96		8400	69,56
18	2300	65,96		5400	63,86		8500	66,63
	2400	69,79		5500	67,13	14	8600	85,53
	2500	69,56	4	5600	78,53		8700	83,73
	2600	68,16		5700	73,84		8800	85,87
19	2700	68,19		5800	69,83		8900	78,46
	2800	72,66		5900	65,86		9000	78,36
	2900	69,23		6000	61,50	15	9100	73,77
21	3000	70,76		6100	76,46	16	9225.4943	63,00
	3100	79,68		6200	84,26			

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Art. x. *Reduction of the Base.*

	Feet.
The overplus of the 273d chain was measured by Mr. Ramsden, and found to be 23,517 feet; wherefore, the apparent length of the base was -	27676,4830
From the measurement in the Riding-house of his Grace the Duke of Marlborough, the chain A was found to exceed 100 feet, in the temperature of 54°, 0,11425 parts of an inch; to which, adding the wear by the measurement on Salisbury Plain, *viz.* $\frac{1}{260}$, and also *half* the wear by the measurement of this base, *viz.* $\frac{1}{100}$ part of an inch, we get $\frac{0,1191}{12}$ for the excess of the chain's length above 100 feet; therefore, $\frac{0,1191}{12} \times 272,8 = 2,7075$ feet; which add - - - -	+2,7075
The sum of all the degrees shewn by the thermometer was 98511; wherefore, $\overline{\frac{98511}{5} - 54^\circ} \times 272,8 \times \frac{0,0075}{12} = 3,1069$ feet; which also add -	+3,1069
Again, from the comparison of the 50-feet chain with the standard B, it appeared that the excess above 50 feet, in the temperature of 54°, was 0,09075 parts of an inch; therefore, $\frac{0,09075}{12} \times 8 = 0,0605$ parts of a foot. This likewise add -	+0,0605
The sum of all the degrees shewn by the thermometers placed by the sides of the 50-feet chain, was 1372; therefore $\overline{\frac{1372}{5} - 54^\circ \times 4} \times \frac{,0075}{12} = 0,0365$ parts of a foot: and this add - -	+0,0365
	27682,3944

27682,3944

And, for the reduction of the base to the temperature of 62°, *viz.* for 8° on the brass scale, we have $\frac{0{,}01237 \times 272{,}8 \times 8°}{12}=2{,}2497$ feet; which subtract —2,2497

Therefore, the length of the base is - - - feet 27680,1447 which, neglecting decimals, may be taken at 27680 feet.

As to the probable error of the above conclusion, I know not how to form a just opinion. On ground sufficiently hard, and otherwise favourable, I think a base of 5 miles might be measured so accurately, as to afford a result not differing from the truth more than three inches: but, on this occasion, I should not suppose the error can be less than six, nor more than nine inches. Motives for adopting this supposition, have been related in a foregoing article.

ART. XI. *Calculation of the Sides of certain principal Triangles in Cornwall and Devonshire.* Plate XXVII.

Distance from Hensbarrow to St. Agnes Beacon, 97084,8 Feet. Phil. Trans. 1797. p. 461.

No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
1.	St. Agnes Beacon	47 10 0,75	—0,15			47 10 3,25	
	Hensbarrow - -	67 6 13,25	—0,58			67 6 13	
	Trevose Head -	65 43 47	—0,57			65 43 43,75	
		180 0 1		1,31	—0,31		
		Trevose Head from St. Agnes Beacon -					98108,1
		Trevose Head from Hensbarrow - -					78099,9

Distance from Hensbarrow to Bodmin Down, 47337,2 Feet. Phil. Trans. 1797. p. 460.

No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
II.	Hensbarrow - -	77 20 18,5	−0,30			77 20 17,5	
	Bodmin Down -	68 21 58,25	−0,32			68 21 57,25	
	Trevose Head -	34 17 45,5	−0,23			34 17 45,25	
		180 0 2,25		0,86	+1,39		
	Trevose Head from { Bodmin Down - -						81967,6
	Trevose Head from { Hensbarrow - -						78093

Mean distance from Hensbarrow to Trevose Head, 78096,4 feet.

No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
III.	Trevose Head -	42 33 52	−0,32			42 33 51,25	
	Bodmin Down -	71 55 27	−0,43			71 55 26,75	
	Cadon Barrow -	. . .				65 30 42,0	
	Cadon Barrow from { Trevose Head - -						85625
	Cadon Barrow from { Bodmin Down - -						60925
IV.	Bodmin Down -	30 58 13	−0,05			30 58 12,75	
	Cadon Barrow - -	43 49 50,5	−0,04			43 49 50	
	Brown Willy - -	. . .				105 11 57,25	
	Brown Willy from { Bodmin Down - -						43722
	Brown Willy from { Cadon Barrow - -						32488

Distance from Carraton Hill to Maker Heights, 82600,3 feet. Phil. Trans. 1797. p. 458.

No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
V.	Carraton Hill - -	74 5 22,5	−0,60			74 5 21,75	
	Maker Heights -	53 4 29	−0,48			53 4 28,75	
	Black Down - -	52 50 9,75	−0,48			52 50 9,5	
		180 0 1,25		1,57	−0,32		
	Black Down from { Maker Heights - -						99680
	Black Down from { Carraton Hill - -						82860,4

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No. of triangles	Names of stations.	Observed angles.	Diff	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″		″	″	° ′ ″	Feet.
VI.	Carraton Hill - -	48 57 8,25	−0,24			48 57 9,25	
	Black Down - -	39 44 39	−0,22			39 44 38,5	
	St. Stephen's Down	91 18 12,75				91 18 12,25	
		180 0 0		0,89	−0,89		
	St. Stephen's Down from Carraton Hill - -						52991,3
	St. Stephen's Down from Black Down - -						62506,7

Distance from Carraton Hill to Kit Hill, 33427 feet. Phil. Trans. 1797. p. 459.

No. of triangles	Names of stations.	Observed angles.	Diff	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
VII.	Carraton Hill - -	70 15 32	−0,14			70 15 32,25	
	St. Stephen's Down	37 1 56	−0,11			37 1 55,75	
	Kit Hill - -	. . .				72 42 32	
	St. Stephen's Down from Carraton Hill - -						52994
	St. Stephen's Down from Kit Hill - - -						52240,4

Mean distance from St. Stephen's Down to Carraton Hill, 52292,7 feet.

No. of triangles	Names of stations.	Observed angles.	Diff	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
VIII.	St. Stephen's Down	54 16 13	−0,19			54 16 12,5	
	Black Down - -	52 57 37	−0,19			52 57 36,5	
	Kit Hill - -	. . .				72 46 11	
	Black Down from Kit Hill - - -						53128
	Black Down from St. Stephen's Down -						62509,2

Hence the mean distance from Black Down to St. Stephen's Down, is 62508 feet.

In the third triangle, the angle at Cadon Barrow is supplementary. When the observations were made at that station, a direction-post at Bodmin Down was mistaken for the staff, (to which it was similar in shape,) erected at no great distance from it. This error was not detected till long after: and, although it has been a maxim to which we have generally adhered, of observing all the angles of

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each triangle, yet, for the reasons assigned in the preface, I have chosen to depart from it on the present occasion. In another principal triangle, the angle at Brown Willy is also supplementary: it has already been mentioned, that an instrument cannot be got on the top of it. As to the angles at Kit Hill, in the two last triangles, being inferred ones, it may be proper to mention, that Black Down was chosen for a station, after the observations were made at the former. To have visited Kit Hill a second time would have been unnecessary, because there are not any distances, except to interior objects, which depend upon those triangles.

ART. XII. *Calculation of the Sides of a Set of principal Triangles, carried on from the Side which joins the Stations on Beacon Hill, near Amesbury, and Wingreen Hill, near Shaftsbury, towards the Base of Verification on King's Sedgemoor.* Plate XXIX.

Distance from Beacon Hill to Wingreen Hill, 114522,4 Feet. Phil. Trans. 1795. p. 501.

No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
IX.	Wingreen Hill -	89 57 37,75	−0,97			89 57 37	
	Beacon Hill -	32 11 43,25	−0,48			32 11 43	
	Bradley Knoll	57 50 58,25	−0,48			57 50 40	
		179 59 59,25		1,93	−2,68		
	Bradley Knoll from Wingreen - -						72074
	Bradley Knoll from Beacon Hill -						135272,3
X.	Bradley Knoll -	40 43 52	−0,26			40 43 51,5	
	Wingreen -	96 20 37	−0,65			96 20 36,25	
	Bull Barrow -	42 55 32,75	−0,25			42 55 32,25	
		180 0 1,75		1,16	+0,55		
	Bull Barrow from Bradley Knoll -						105180
	Bull Barrow from Wingreen - -						69053,6

In the Philosophical Transactions for 1797, p. 455, the distance from Bull Barrow to Wingreen is said to be 69058, being 4½ feet greater than the above conclusion.

No of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
XI.	Bull Barrow -	40 38 47,75	−0,28			40 38 45,25	
	Bradley Knoll	45 43 3,5	−0,28			45 43 3,25	
	Ash Beacon -	93 38 12,5	−0,65			93 38 11,5	
		180 0 3,75		1,25	+2,50		
	Ash Beacon from Bradley Knoll -						68650,6
	Ash Beacon from Bull Barrow -						75451
XII.	Beacon Hill -	23 4 15	−0,08			23 4 14,75	
	Bradley Knoll	42 43 29,75	+0,07			42 43 28,25	
	Westbury Down	114 12 18,5	−0,97			114 12 17	
		180 0 3,25		1,17	+2,08		
	Westbury Down from Beacon Hill -						100625,1
	Westbury Down from Bradley Knoll -						58118,2
XIII.	Westbury Down	40 48 1,75	−0,12			40 48 1,75	
	Bradley Knoll -	101 23 59	−0,48			101 23 59,75	
	Mendip Hills -	37 47 58,5	−0,16			37 47 58,5	
		179 59 59,25		0,77	−1,52		
	Mendip Hills from Westbury Down -						92954,0
	Mendip Hills from Bradley Knoll -						61961,1

Base of verification.—Greylock's Foss to Lugshorn Corner, 27680 feet.

No of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
XIV.	Lugshorn Corner	107 44 31				107 44 31	
	Greylock's Foss -	8 30 0				8 30 0	
	Dundon Beacon -	63 45 29				63 45 29	
		180 0 0			0		
	Dundon Beacon from Lugshorn Corner -						4561,5
	Dundon Beacon from Greylock's Foss						29393

No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances
		° ′ ″	″	″	″	° ′ ″	Feet.
XV.	Greylock's Foss -	105 40 0,25				105 40 0,5	
	Moor Lynch -	59 58 14				59 58 14,5	
	Dundon -	14 21 44,75				14 21 45	
		179 59 59			−1,0		
	Moor Lynch from { Greylock's Foss -						8421,5
	Dundon Beacon -						32688,7
XVI.	Lugshorn Corner -	13 51 59				13 51 58,75	
	Greylock's Foss -	114 9 59				114 9 58,5	
	Moor Lynch -	51 58 3,25				51 58 2,75	
		180 0 1,25			+1,25		
	Moor Lynch from { Lugshorn Corner -						32061,3
	Greylock's Foss -						8421,8
XVII.	Lugshorn Corner -	93 52 33,75				93 52 34,25	
	Moor Lynch -	8 0 10,25				8 0 10,75	
	Dundon Beacon -	78 7 14,5				78 7 15	
		179 59 58,5			−1,5		
	Dundon Beacon from { Lugshorn Corner -						4561,5
	Moor Lynch -						32689,0

Hence the mean distance from Moor Lynch to Dundon Beacon is 32688,85 feet.

No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances
XVIII.	Moor Lynch -	54 38 50	−0,07			54 38 49,5	
	Dundon Beacon -	101 22 54,5	−0,32			101 22 53,75	
	Mendip Hills -	23 58 17	−0,10			23 58 16,75	
		180 0 1,5		0,5	+1,0		
	Mendip Hills from { Moor Lynch - -						78876,8
	Dundon Beacon -						65622,7

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No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
XIX.	Moor Lynch -	54 3 22,5	−0,42			54 3 22	
	Mendip Hills -	69 26 48,25	−0,49			69 26 47	
	Ash Beacon -	56 29 51,5	−0,42			56 29 51	
		180 0 2,25		1,33	+0,92		
	Ash Beacon from Moor Lynch - -						88571
	Ash Beacon from Mendip Hills -						76851
XX.	Mendip Hills -	58 16 22	−0,30			58 16 21,5	
	Ash Beacon -	50 8 45,5	−0,28			50 8 45,25	
	Bradley Knoll -	71 34 55	−0,36			71 34 54,25	
		180 0 2,5		0,95	+1,55		
	Bradley Knoll from Mendip Hills -						61963,5
	Bradley Knoll from Ash Beacon - -						68653,6

The distance from Bradley Knoll to the station on Mendip Hills, and also to that on Ash Beacon, is given in the preceding triangles, independent of the above values. The first is 61961,1, and the second 68650,6 feet: these distances have their origin in the base on Salisbury Plain. The other distances are 61963,5, and 68653,6 feet; and these depend on the base of verification on King's Sedgemoor. There is, therefore, a difference of $2\frac{4}{10}$ feet between the values of one distance, (12 miles nearly,) and 3 feet between those of the other, which is about 13 miles in length. If the computations had been carried on from one base to another, the difference between the measured base on Sedgemoor and the computed base, would have appeared to be *one foot nearly*. I have already delivered it as my opinion, that an error of nine inches may exist in the new base: therefore, these results must be considered as satisfactory enough. A different correction of the observed angles, or another selection of

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the angles themselves, might afford a closer agreement; but I can see no just reason for making any alterations in one or the other. I shall now take the means of the distances, as derived from both bases, and consider 68652,2 feet as the true distance from Ash Beacon to Bradley Knoll; and 61962,3 feet for that between Bradley Knoll and the station on Mendip Hills.

In one of the foregoing triangles, (Bull Barrow, Bradley Knoll, and Ash Beacon,) the distance between Ash Beacon and Bull Barrow is found to be 75451 feet. If the *mean distance* between Bradley Knoll and Ash Beacon, *viz.* 61962,3 feet, be now used, 75452,7 feet becomes the distance between those stations; and this I shall use, in computing the sides of the two triangles which immediately follow.

No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
XXI.	Ash Beacon -	34 18 56,25	−0,14			34 18 55,75	
	Bull Barrow -	51 26 42	−0,13			51 26 41,75	
	Mintern - -	94 14 23	−0,32			94 14 22,5	
		180 0 1,25		0,59	+0,66		
	Mintern from { Ash Beacon - -						59166,6
	Mintern from { Bull Barrow -						42653,7
XXII.	Pilsden - -	35 3 1	−0,24			35 3 0,75	
	Ash Beacon -	49 21 38,25	−0,24			49 21 38	
	Mintern -	95 35 22	−0,60			95 35 21,25	
		180 0 1,25		1,08	+0,17		
	Pilsden from { Ash Beacon - -						102535
	Pilsden from { Mintern - -						78177,6

In our last account, (see Phil. Trans. 1797. p. 455 and 456,) the distance from Bull Barrow to Mintern was found to be 42653,4 feet; and the distance from Pilsden to Mintern 78177 feet. The distances derived from the above triangles are very nearly the same; a difference of a few inches only existing between them.

No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
XXIII.	Moor Lynch -	57 19 3,5	−0,64			57 19 2,5	
	Ash Beacon -	76 2 36,5	−0,39			76 2 36	
	Pilsden - -	. . .				46 38 21,5	
		Pilsden from Moor Lynch - -					118230

But Pilsden was also observed from Dundon Beacon; from which, and the angle observed at Moor Lynch, between Dundon Beacon and Pilsden, results the following triangle.

XXIV.	Moor Lynch - -	56 43 36,75	+0,03			56 43 36,5	
	Dundon Beacon -	108 1 52	−0,64			108 1 51,75	
	Pilsden - -	. . .				15 14 31,75	
		Pilsden from Moor Lynch - - - -					118233,6

Hence, the mean distance from Moor Lynch to Pilsden is 118231,8 feet; and this is the side from which the series about to be carried on, for the survey of the north of Devonshire, is to originate.

In the triangle formed by the stations on Mendip Hills, Bradley Knoll, and Westbury Down, the distance between the first and last is 92954,0 feet; but, computing with the mean distance from Mendip to Bradley Knoll, (61962,3 feet,) as found from both bases, the distance from Mendip to Westbury Down proves to be 92955,9 feet; which distance is used in the remaining principal triangles in this quarter.

XXV.	Farley Down - -	77 21 53,75	−0,44			77 21 52,75	
	Westbury Down -	63 42 51,25	−0,34			63 42 49,75	
	Mendip Hills -	38 55 17,5	−0,32			38 55 17,5	
		180 0 2,5		1,10	+1,40		
		Mendip from Farley Down - - -					85412,2
		Mendip from Westbury Down - -					92955,9

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No. of triangles.	Names of stations.	Observed angles	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
XXVI.	Mendip	60 36 15,5	−0,40			60 36 15	
	Dundry	69 52 22	−0,44			69 52 22	
	Farley Down	49 31 23,5	−0,37			49 31 23	
		180 0 1		1,21	−0,21		
	Dundry from Farley Down						79255,3
	Dundry from Mendip						69196
XXVII.	Mendip	41 3 58,5	−0,25			41 3 58,25	
	Dundry	83 34 18	−0,40			83 34 17,5	
	Lansdown	. . .				55 21 44,25	
	Lansdown from Mendip						83573,2
	Lansdown from Dundry						55249,2
XXVIII.	Dundry	13 41 56,25	−0,09			13 41 56	
	Farley Down	27 5 27,5	−0,11			27 5 27,25	
	Lansdown	. . .				139 12 36,75	
	Lansdown from Farley Down						28730,4
	Lansdown from Dundry						55248,7

Wherefore, the mean distance from Dundry to Lansdown is 52248,9 feet.

ART. XIII. *Calculation of the sides of certain principal Triangles, carried on from the side Bagshot Heath and Highclere, towards the north.* Plate XXXI.

Distance from Bagshot Heath to Highclere, 142952,6 feet. Phil. Trans. 1795. p. 496.

XXIX.	Bagshot Heath	55 32 26	−0,89			55 32 25,25	
	Highclere	46 10 18,25	−0,83			46 10 17,75	
	Nuffield	78 17 18,25	−1,20			78 17 17	
		180 0 2,5		2,94	−0,43		
	Nuffield from Bagshot Heath						105321,2
	Nuffield from Highclere						120374

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No. of triangles.	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
XXX.	White Horse Hill	63 7 53,25	−0,94			63 7 53,5	
	Highclere - -	63 18 16,75	−0,94			63 18 17	
	Nuffield - -	53 33 49,5	−0,86			53 33 49,5	
		179 59 59,5		2,74	−3,24		
	White Horse Hill from Nuffield - -						120557,7
	White Horse Hill from Highclere - -						108563,1

Distance from Beacon Hill to Highclere, 98694,4 feet. Phil. Trans. 1795. p. 497.

No. of triangles.	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
XXXI.	Beacon Hill - -	17 42 38,5	−0,12			17 42 38,25	
	Highclere - -	56 0 29,75	+0,08			56 0 29,25	
	Inkpin Hill - -	106 16 53,25	−0,47			106 16 52,5	
		180 0 1,5		0,50	+1,0		
	Inkpin Hill from Highclere - -						31278,8
	Inkpin Hill from Beacon Hill - -						85247,9
XXXII.	Highclere - -	34 27 50,75	+0,38			34 27 50,75	
	Inkpin Hill -	133 27 57,5	−0,91			133 27 58	
	White Horse Hill	12 4 11,5	+0,04			12 4 11,25	
		179 59 59,75		0,49	−1,24		
	White Horse Hill from Highclere - -						108565,5
	White Horse Hill from Inkpin - - -						84647,1

In the following computations, I shall use 120557,7 feet for the distance between White Horse Hill and Nuffield: this is derived from the base on Hounslow Heath. By the last triangle, White Horse Hill, from Highclere, is distant 108565,5 feet; which is computed from the base on Salisbury Plain. The distance between those stations, found by the second of the above triangles, is 108563,1 feet. Therefore, whether the distance between White Horse Hill and Nuffield be founded on the base measured on Salisbury Plain, or Hounslow Heath, nearly the same conclusion is derived: the difference will

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not amount to four feet; a small quantity in a side of three-and-twenty miles. I shall, however, use 120557,7, because I think it the most accurate determination.

No. of triangles.	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances
		° ′ ″	″	″	″	° ′ ″	Feet
XXXIII.	White Horse Hill	38 48 13,25	−0,67			38 48 12,5	
	Nuffield - -	86 4 16,25	−1,21			86 4 15	
	Brill - -	55 7 33,5	−0,71			55 7 32,5	—
		180 0 3		2,6	+0,4		
	Brill from { White Horse Hill - -						146603,2
	Brill from { Nuffield - - -						92085,5
XXXIV.	Brill - -	50 14 44,5	−1,18			50 14 45	
	White Horse Hill	64 45 43,75	−1,34			64 45 42,5	
	Stow on the Wold	64 59 32	−1,35			64 59 45	—
		180 0 0,25		3,88	−3,63		
	Stow from { White Horse Hill - -						124365,6
	Stow from { Brill - - - -						146326,3
XXXV.	Brill - -	32 34 43	−0,61			32 34 42,25	
	Stow - -	60 56 6,25	−0,64			60 56 5,5	
	Epwell - -	86 29 13,5	−1,11			86 29 12,25	
		180 0 2,75		2,37	+0,38		
	Epwell from { Stow - - - -						78938,2
	Epwell from { Brill - - -						128140
XXXVI.	Epwell - -	38 10 44	−0,25			38 10 42,75	
	Stow - -	72 38 49,5	−0,34			72 38 47,5	
	Broadway Beacon	69 10 31,75	−0,32			69 10 29,75	
		180 0 5,25		0,92	+4,33		
	Broadway Beacon from { Stow - - - -						52203,2
	Broadway Beacon from { Epwell - - -						80611,4

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No. of triangles.	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
XXXVII.	Broadway Beacon	56 32 45	−0,34			56 32 44,75	
	Epwell	95 34 25,25	−1,62			95 34 24,75	
	Corley	27 52 49,75	−0,61			27 52 50,5	
		180 0 0		1,58	−1,58		
	Corley from Broadway Beacon						171568
XXXVIII.	Brill	34 23 58,5	−0,65			34 23 57,5	
	Epwell	85 0 18,5	−1,10			85 0 17,5	
	Arbury Hill	60 35 45,5	−0,70			60 35 57,5	
		180 0 2,5		2,46	−0,04		
	Arbury Hill from Epwell						83098,4
	Arbury Hill from Brill						146530
XXXIX.	Arbury Hill	89 57 4,5	−1,14			89 57 5,5	
	Epwell	54 45 18,75	−0,57			54 45 18,25	
	Corley	35 17 36,75	−0,57			35 17 36,25	
		180 0 0		2,29	−2,29		
	Corley from Arbury Hill						117463
	Corley from Epwell						143827,8

By the triangle Broadway Beacon, Epwell, Corley, (see the above) the distance from Corley to Broadway Beacon is the only distance computed; and this has been obtained through the means of two observed angles only. When the observations were made at Broadway Beacon, it was not imagined Corley could be seen; and the contrary was not known till the party arrived at the latter place. In so large a triangle, it would certainly be right to observe all the angles: but I have given the angles as they now stand, because the distance from Epwell to Corley comes out 143831 feet, which determination differs only three feet from the same distance found by the last triangle.

XL.	Bow Brickhill	68 22 56,75	−1,21			68 22 59	
	Arbury Hill	43 16 55,5	−0,99			43 16 54,5	
	Brill	68 20 7,75	−1,22			68 20 6,5	
		180 0 0		3,43	−3,43		
	Bow Brickhill from Arbury Hill						146481
	Bow Brickhill from Brill						108058,9

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It will now be expedient to compute the distance from Bow Brick-hill to Brill, by means of another set of triangles. And it was for the express purpose of verifying this distance found by the last triangle, that Scutchamfly Barrow, in Berkshire, and the station above Wendover, were chosen. The base on which these triangles are to rest, is the distance between Nuffield and White Horse Hill, *viz.* 120557,7 feet.

No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
XLI.	Nuffield -	62 32 5,25	−0,53			62 32 6	
	White Horse Hill	35 34 23,25	−0,47			35 34 24	
	Shotover Hill -	81 53 29,75	−0,74			81 53 30	
		179 59 58,25		1,75	−3,5		
	Shotover Hill from White Horse Hill -						108050,2
	Shotover Hill from Nuffield - -						70842,1
XLII.	Shotover Hill -	26 8 8	−0,12			26 8 8	
	White Horse Hill	42 4 2	−0,04			42 4 2	
	Scutchamfly Barrow	111 47 50	−0,70			111 47 50	
		180 0 0		0,86	−0,86		
	Scutchamfly Barrow from White Horse Hill -						51261,9
	Scutchamfly Barrow from Shotover Hill - -						77968,3
XLIII.	Shotover Hill -	117 30 56	−1,41			117 30 55,25	
	Scutchamfly Barrow	34 26 52	−0,01			34 26 52	
	Wendover -	28 2 12,75	−0,09			28 2 12,75	
		180 0 0,75		1,52	−0,77		
	Wendover from Scutchamfly Barrow -						147113,3
	Wendover from Shotover - -						93828,6

No. of triangles	Names of Stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
XLIV.	Wendover -	23 23 57,5	0,11			23 23 57,25	
	Shotover Hill -	48 30 39,75	0,04			48 30 40,5	
	Brill - -	. . .				108 5 22,25	
				1,21			
	Brill from { Wendover - -						73940,3
	Brill from { Shotover Hill -						39200,2
XLV.	Wendover -	80 11 9,25	−0,67			80 11 8,5	
	Brill - -	57 25 1,5	−0,47			57 25 0,75	
	Bow Brickhill -	42 23 50,75	−0,44			42 23 50,75	
		180 0 1,51		1,58	−0,07		
	Bow Brickhill from { Wendover - -						92400,7
	Bow Brickhill from { Brill - - -						108055

According to the first determination, the distance from Bow Brickhill to Brill is 108058,9 feet, and by the last, 108855 feet. There is, therefore, a difference of 4 feet nearly; a quantity which must be deemed inconsiderable; hence, 108056,9 feet may be taken for the true distance.

No. of triangles	Names of Stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
XLVI.	Kinsworth -	62 55 38,75				62 55 38,5	
	Bow Brickhill -	88 42 0				88 41 59,25	
	Brill - -	. . .				28 22 22,25	
	Kinsworth from { Brill - -						121322,5
	Kinsworth from { Bow Brickhill - -						57668
XLVII	Wendover -	33 26 48				33 26 49	
	Quainton - -	94 58 37				94 58 38	
	Brill - -	51 34 33				51 34 33	
		179 59 58		0,55	−2,55		
	Quainton from { Brill - -						40908
	Quainton from { Wendover - -						58146,4

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No. of triangles	Names of Stations.	Angles observed.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
XLVIII	Bow Brickhill -	38 51 40,75				38 51 40,75	
	Wendover - -	46 44 29,5				46 44 29,25	
	Quainton -	94 23 50,25				94 23 50	
		180 0 1,25		0,83	+0,42		
						Quainton from { Wendover - -	58146,9
						Bow Brickhill -	67491,3

In the above triangle, I have computed the distances of Wendover and Bow Brickhill from Quainton with 92400,7 feet, the side Wendover and Bow Brickhill, as determined in a former triangle.

XLIX.	Bow Brickhill -	85 9 52,75				85 9 52	
	Kinsworth -	52 17 56,75				52 17 56	
	Quainton - -	. . .				42 32 12	
						Quainton from { Kinsworth - -	84997
						Bow Brickhill -	67490,3

Therefore, 67490 may be considered as nearly the true distance, in feet, between Quainton and Bow Brickhill.

L.	Bow Brickhill -	42 10 36,75				42 10 36,5	
	Kinsworth -	82 50 30,5				82 50 30	
	Lillyhoe. - -	54 38 53				54 38 53,5	
		180 0 0,25		1,26	−1,50		
						Lillyhoe from { Kinsworth -	47278,7
						Bow Brickhill -	69867

As the stations Lidlington, Trusler Hill, together with Crouch Hill, Cumner Hill, and Whiteham Hill, have been used for purposes of greater importance than secondary ones have been generally applied to, I shall insert the triangles formed by their intersections in this article.

No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
LI.	Kinsworth -	31 4 5				31 4 4	
	Bow Brickhill -	80 39 37,25				80 39 34,75	
	Lidlington -	68 16 22,25				68 16 21,25	
		180 0 4,5		0,42	+4,92		
	Lidlington from Bow Brickhill -						32035,6
	Lidlington from Kinsworth -						61255,3
LII.	Lillyhoe - -	78 58 26				78 58 26	
	Kinsworth -	51 46 22				51 46 22	
	Lidlington -	. . .				49 15 12	
	Lillyhoe from Kinsworth - -						47280
	Lillyhoe from Lidlington -						49025

The distance from Lillyhoe to Kinsworth, as found in a former triangle, is 47278,1 feet, and by the last 47280 feet; therefore, 47279,3 may be taken for the true distance in feet.

No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
LIII.	Bow Brickhill -	38 28 56				38 28 56	
	Lillyhoe - -	23 59 31				23 59 31	
	Lidlington -	. . .				117 31 33	
	Lillyhoe from Lidlington - -						49027,3
	Lillyhoe from Bow Brickhill - -						69869

And this triangle, with that preceding it, gives the mean distance between Lillyhoe and Lidlington = 49026,1 feet; and, with the triangle Lillyhoe, Kinsworth, and Bow Brickhill, it assigns 69868 feet for the mean distance between Lillyhoe and Bow Brickhill.

No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
LIV.	Lillyhoe - -	5 52 11,5				5 52 11,5	
	Bow Brickhill -	14 54 42,75				14 54 42,75	
	Trusler Hill -	. . .				159 13 5,75	
	Trusler Hill from Bow Brickhill -						20138,7
	Trusler Hill from Lillyhoe - -						50673,6

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No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
LIV.	Crouch Hill -	145 23 26,25				145 23 26	
	Epwell - -	27 3 10				27 3 10	
	Brill - -	. . .				7 33 24	
	Crouch Hill from { Brill - -						102608
	{ Epwell - -						29668,8

Distance from White Horse Hill to Shotover Hill 108050,2 feet.

No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
LV.	Shotover Hill -	48 5 32,75				48 5 32,25	
	White Horse -	16 59 53,75				16 59 53,25	
	Whiteham Hill -	114 54 34,75				114 54 34,5	
		180 0 1,25					
	Whiteham Hill from { White Horse Hill -						88662,2
	{ Shotover Hill -						34827,4
LVI.	Whiteham Hill -	55 52 35				55 52 36	
	Shotover Hill -	24 37 36				24 37 37	
	Cumner Hill -	99 29 48,5				99 29 47	
		179 59 59,5					
	Cumner Hill from { Shotover Hill - -						29231,5
	{ Whiteham Hill -						14714,3

And, because the Observatory of his Grace the Duke of MARLBOROUGH, at Blenheim, together with that at Oxford, have been observed with the same care and attention as the principal stations, and also because precise determinations of the situations are of great importance, I shall here insert the triangles formed by their intersections.

No. of triangles	Names of stations.	Observed angles.	Diff	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
LVII.	Shotover Hill - -	23 11 5				23 11 5	
	Cumner Hill - -	29 23 33				29 23 33	
	The Atlas on the top of the Observatory at Oxford	. . .				127 25 22	
	Oxford Observatory from { Cumner Hill - -						14492
	Shotover Hill - -						18065,1
LVIII.	Whiteham Hill -	131 25 36,5				131 25 35.5	
	White Horse Hill -	10 30 43,5				10 30 43.75	
	Blenheim Observatory	. . .				38 3 40.75	
	Blenheim Observatory from { White Horse Hill -						107831,9
	Whiteham Hill - -						26237,6

ART. XIV. *Triangles for connecting the Series carried on from Scutchamfly Barrow and White Horse Hill, in Berkshire, into Buckinghamshire and Bedfordshire, with the Series carried on for the Survey of Essex.*

The angle at St. Ann's Hill, between the station on Hanger Hill Tower and Hampton Poor House, inferred from General ROY's Account, is 25° 33′ 58″,5. In 1793, the angle between the staff on Pen Church Tower and Hampton Poor House was taken, and found = 95° 57′ 34″,5; therefore, the angle between Pen Tower and Hanger Hill is 70° 23′ 36″.

The distance from St. Ann's Hill to Pen is determined by

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the following triangle, in which the distance between St. Ann's Hill and Bagshot Heath, *viz.* 46955,3 feet, (see Phil. Trans. for 1795, p. 496,) is used for the base.

No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
LIX.	St. Ann's Hill	80 43 48				80 43 48	
	Bagshot - -	70 30 37				70 30 37	
	Pen Tower -	. . .				28 45 35	
	Pen Tower from St. Ann's Hill - -						92000,5
	Pen Tower from Bagshot Heath - -						96318

The distance from St. Ann's Hill to Hanger Hill Tower is 68895,8 feet: this is derived from the *mean* length of the base on Hounslow Heath. This side, together with St. Ann's Hill and Pen, using the included angle at St. Ann's Hill, as found above, give 94640,5 feet, for the distance between Pen and Hanger Hill Towers.

The angle at St. Ann's Hill, between Bagshot Heath and Hanger Hill Tower, is 151° 7′ 24″,25: this, with the sides Bagshot Heath and St. Ann's, St. Ann's and Hanger Hill, give 17° 13′ 48″, for the angle at Bagshot Heath, between Hanger Hill Tower and St. Ann's Hill: hence we have the following triangle.

Bagshot Heath - -	16° 45′ 43″
Hanger Hill - -	103 18 23
Stanmore - -	59 55 54

Which triangle gives 37431 feet, for the distance between Stanmore and Hanger Hill Tower.

The angle at the station on Bow Brickhill, (see the preceding article,) between Wendover and Kinsworth, is 46° 18′ 8″,5; and the distances from it to these stations are 92402,2 feet, and 57668 feet respectively: these give the following triangle.

Bow Brickhill -	46°	18′	8″,5
Wendover - -	38	25	21,25
Kinsworth - -	95	16	30,25

From which the distance between Wendover and Kinsworth is found = 67090,7 feet. The observed angle at Wendover, between Bow Brickhill and Stanmore, is 102° 22′ 29″; from which, subtracting 38° 25′ 21″,25, the angle between Bow Brickhill and Kinsworth, we get 63° 57′ 7″,75, for the angle between Kinsworth and Stanmore. Again, the observed angle at Kinsworth, between Bow Brickhill and Stanmore, is 173° 37′ 44″; from which, subtracting the angle between Bow Brickhill and Wendover, we get 78° 21′ 13″,75, for the angle between Stanmore and Wendover. If these *computed* angles are actually such as might be observed, were Kinsworth and Wendover visible from each other, the angle at Stanmore between those stations ought to be 37° 41′ 39″, nearly: but the observed angle was 37° 41′ 41″,75; which is so nearly the computed one, as to leave little doubt of the accuracy of those *data* from which the angles are derived. The distance from Wendover to Kinsworth is 67090,7 feet.

	°	′	″
Wendover -	63	57	7,75
Kinsworth -	78	21	13,75
Stanmore - -	37	41	41,75
	180	0	3,25

which, corrected for calculation, becomes,

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Wendover -	63° 57′ 7″
Kinsworth -	78 21 12
Stanmore -	37 41 41 which triangle gives

the distance of Stanmore from $\left\{\begin{array}{l}\text{Wendover} = 107464{,}1 \\ \text{Kinsworth} = 98577{,}5\end{array}\right\}$ feet.

In consequence of Bushy Heath intercepting the view towards the east from Stanmore, it became necessary to choose a station on the former. To determine the distance, the angles at the two stations were taken very accurately; they were as follows,

Stanmore -	42 11 21,5
Bushy Heath	135 35 40,5
Kinsworth,	. . . which gives 5483,3 feet for the required distance.

To determine the distance of the station on Pen Church Tower, we have two angles in the following triangle, *viz.*

Wendover -	38 13 18	which, corrected for calculation, becomes,
Stanmore -	23 44 48	
Pen Tower -	118 1 54	

Wendover -	38 13 18,25
Stanmore -	23 44 48,25
Pen Tower -	118 1 54,5 which triangle gives

the distance of Pen from $\left\{\begin{array}{l}\text{Wendover} = 49027 \\ \text{Stanmore} = 75325{,}4\end{array}\right\}$ feet.

With this distance of Stanmore from Pen, found from the last triangle, and also that between Stanmore and Hanger Hill, derived from the triangle, Bagshot Heath, Hanger Hill, and Stanmore, together with the included angle at Stanmore, *viz.* 109′ 28′ 22″,5, we get the distance of Pen to Hanger Hill Tower = 94631,8 feet. The same distance has been found before, in a shorter and more direct way, being 94640,5 feet: the difference is only 8,7 feet; a sufficient proof that the distances given for the survey of this intricate and woody country, are

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sufficiently correct. It will be more convenient to show how these triangles are connected with those to the eastward, when I arrive at that part of the work which treats of the survey of Essex, than at present. I shall, therefore, proceed to the following article, after observing, that by the help of Harrow Spire, (the situation of which has been determined by General Roy,) and by observations hereafter to be made with the small instrument on Pen Tower, less difficulty will occur in the interior survey than was at first expected.

ART. XV. *Triangles formed by the intersections of Churches, Windmills, and other Objects.*

Triangles.	Angles observed.	Distances of the Stations from the intersected Objects.	
	° ′ ″		Feet.
Little Haldon	23 54 50	Great Haldon	18974
Ball's Obelisk	132 41 8		19366
Great Haldon, secondary station			
Great Haldon from Ball's Obelisk 19366 feet.			
Great Haldon	68 0 35	Topsham Steeple	28316
Ball's Obelisk	71 32 30		27679
Topsham Steeple			
Little Haldon from Furland 72776 feet.			
Little Haldon	18 2 2	Hope's Nose	37656
Furland	18 42 53		39028
Hope's Nose, secondary station			
Bodmin from Trevose 81967,6 feet.			
Bodmin	15 48 43	St. Minvern Steeple	45936
Trevose	21 28 36		36866
St. Minvern Steeple			
Bodmin	12 5 33	St. Minvern Windmill	34852
Trevose	8 46 51		48478
St. Minvern Windmill			

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Trevose from Cadon Barrow 85624,8 feet.

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
Trevose - - - Cadon Barrow - - *St Isey Steeple*	° ′ ″ 55 38 59 19 15 48	St. Isey Steeple -	29256 73216
Trevose - - Cadon Barrow - - *St. Merian Steeple*	58 41 39 6 38 22	St. Merian Steeple -	10894 80504

Black Down from St. Stephen's 62506,7 feet.

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
Black Down - - St. Stephen's Down - - *Werrington Steeple*	4 46 37 74 20 14	Werrington Steeple -	61289 5301
Black Down - - - St. Stephen's - - *Boyton Steeple*	15 18 49 104 53 9	Boyton Steeple -	69897 19101
Black Down - - St. Stephen's - - *St. Stephen's Steeple*	1 8 22 30 7 22	St. Stephen's Steeple	60448 2395
Black Down - - St. Stephen's - - *North Petherwin Steeple*	5 31 36 153 13 23	North Petherwin Steeple	77698 16610

Carraton from St. Stephen's 52994 feet.

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
Carraton - - St. Stephen's - - *Stokeclimsland Steeple*	50 40 15 38 21 4	Stokeclimsland Steeple	32886 40997
Carraton - - St. Stephen's - - *Launceston Steeple*	6 11 7 55 32 16	Launceston Steeple	49613 6483
Carraton - - - St. Stephen's - - - *Launceston Chapel*	5 58 26 53 7 35	Launceston Chapel -	49404 6427

Long Knoll from Westbury 58118,2 feet.

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
Long Knoll - - - Westbury - - - *Frome Steeple*	45 5 0 34 53 50	Frome Steeple -	33765 41793

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Lansdown from Farley Down 28730,4 feet.

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
Lansdown Farley Down *Cold Aston*	° ′ ″ 56 43 16 28 2 35	Cold Aston	13563 24120

Moor Lynch from Dundon 32688,8 feet.

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
Moor Lynch Dundon *Walton Windmill*	15 54 56 23 11 6	Walton Windmill	20406 14213
Moor Lynch Dundon *Westonzoyland Steeple*	123 0 11 19 18 55	Westonzoyland Steeple	17688 44848
Moor Lynch Dundon *Middlezoy Steeple*	91 5 56 25 26 0	Middlezoy Steeple	15691 36530
Moor Lynch Dundon *Chedzoy Steeple*	153 58 50 9 39 13	Chedzoy Steeple	19454 29556
Moor Lynch Dundon *Highbam Windmill*	29 20 18 46 30 22	Highham Windmill	24457 16518
Moor Lynch Dundon *Highbam Steeple*	36 25 56 39 51 57	Highham Steeple	21567 19982
Moor Lynch Dundon *Bridgewater Spire*	147 57 0 16 15 14	Bridgewater Spire	33656 63768
Moor Lynch Dundon *Burton Pynsent Obelisk*	69 52 39 63 18 59	Burton Pynsent Obelisk	40063 42101
Moor Lynch Dundon *Somerton Steeple*	12 12 41 129 45 57	Somerton Steeple	40792 11221

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Dundry from Lansdown 55248,9 feet.

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
	° ′ ″		Feet.
Dundry Lansdown *Puckle Church Steeple*	22 7 16 85 25 0	Puckle Church Steeple	57757 21819
Dundry Lansdown *Westleigh Steeple*	30 37 18 86 18 39	Westleigh Steeple	61842 31566
Dundry Lansdown *Bristol Cathedral*	51 19 11 22 23 3	Bristol Cathedral	21920 44935
Dundry Lansdown *Redcliff Steeple*	44 18 9 21 22 24	Redcliff Steeple	22096 42346
Dundry Lansdown *Long Aston Steeple*	78 18 19 14 32 8	Long Aston Steeple	13883 54168
Dundry Lansdown *Clifden Windmill*	67 33 51 13 17 8	Clifden Windmill	12860 51725
Dundry Lansdown *Blaze Castle*	75 37 25 39 7 35	Blaze Castle	38391 58932
Dundry Lansdown *Penpole Park Gazebo*	89 10 18 32 52 56	Penpole Park Gazebo	35391 65180
Dundry Lansdown *St. George's Steeple*	32 16 31 31 49 52	St. George's Steeple	32391 32795
Dundry Lansdown *Duke of Beaufort's House, Stoke*	44 54 50 48 5 1	Duke of Beaufort's House	41168 39064
Dundry Lansdown *Harfield Steeple*	57 15 32 39 14 57	Harfield Steeple	35182 46773

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Triangles.	Angles observed.	Distances of the Stations from the intersected Objects	Feet.
	° ' ''		
Dundry - - - - Lansdown - - - - *Durham Steeple*	13 58 8 120 8 3	Durham Steeple -	66541 18573
Dundry - - - - Lansdown - - - - *Knowle Steeple*	63 45 11 59 9 55	Knowle Steeple -	56512 59030
Dundry - - - - Lansdown - - - - *Mangotsfield Steeple*	29 42 10 59 59 41	Mangotsfield Steeple -	47845 27376
Dundry - - - - Lansdown - - - *Winterbourn Steeple*	46 12 31 66 38 49	Winterbourn Steeple -	50045 43280

Mendip from Dundry 69196 feet.

Dundry - - - - Mendip - - - - *Leigh Steeple on Mendip*	15 0 54 104 10 15	Leigh Steeple on Mendip	76847 20533
Dundry - - - - Mendip - - - - *Dundry Steeple*	90 22 22 1 10 22	Dundry Steeple -	1417 69221

Mendip from Long Knoll 61962,3 feet,

Long Knoll - - - - Mendip - - - - *Doulting Spire*	7 20 24 25 42 22	Doulting Spire -	49286 14517

Farley Down from Westbury 59849,5 feet,

Westbury - - - - Farley Down - - - - *Devizes Steeple*	81 25 20 44 6 53	Devizes Steeple -	51197 72726

Whitehorse from Scutchamfly 51261,9 feet.

Whitehorse - - - - Scutchamfly - - - - *Abingdon Spire*	32 55 51 104 3 27	Abingdon Spire -	72898 40852

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Triangles.	Angles observed.	Distances of the Stations from the intersected Objects.	
	° ′ ″		Feet.
Whitehorse - - - Scutchamfly - - - *Wallingford Steeple*	10 39 30 158 52 26	Wallingford Steeple -	101693 52185
Whitehorse - - - Scutchamfly - - *Great Coxwell Windmill*	121 19 20 21 7 0	Great Coxwell Windmill	30295 71834
Whitehorse - - - Scutchamfly - - *Highworth Steeple*	153 24 7 11 21 56	Highworth Steeple -	38449 87355
Whitehorse - - - Scutchamfly - - - *Drayton Steeple*	28 6 9 99 45 35	Drayton Steeple -	63991 30586
Whitehorse - - - Scutchamfly - - - *Radley Steeple*	34 8 57 109 33 56	Radley Steeple -	81618 48624
Whitehorse - - - Scutchamfly - - - *Buckland Steeple*	75 25 57 44 15 50	Buckland Steeple -	41189 57115
Whitehorse - - - Scutchamfly - - - - *Witney Steeple*	81 19 12 62 34 49	Witney Steeple -	57229 86007
Whitehorse - - - Scutchamfly - - - *Bampton Steeple*	90 57 40 48 27 50	Bampton Steeple -	58992 78799

Whiteham from Brill 62066,1 feet.

Whiteham - - - - Brill - - - - - *Islip Steeple*	19 47 5 14 55 46	Islip Steeple - -	28983 38073
Whiteham - - - - Brill - - - - *Woodstock Steeple*	78 47 7 25 3 58	Woodstock Steeple -	27956 64725
Whiteham - - - - Brill - - - - *Kidlington Spire*	38 39 25 18 59 22	Kidlington Spire -	24677 47373

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Whitehorse from Brill 146603,2 feet.

Triangles.	Angles observed.	Distances of the Stations from the intersected Objects.	Feet.
Whitehorse - - - - Brill - - - - *Witchwood Forest Beacon*	° ′ ″ 46 10 15 40 32 9	Witchwood Forest Beacon	95439 105936

Broadway from Epwell 80611,4 feet.

Broadway - - - - Epwell - - - - - *Warwick Steeple*	46 51 21 85 48 34	Warwick Steeple -	109337 79992
Broadwzy - - - - Epwell - - - - - *St. Martin's Spire, Coventry*	49 43 19 100 10 39	St. Martin's, Coventry -	158205 122627
Broadway - - - - Epwell - - - - - *Soleyhull Spire*	71 52 32 74 53 55	Soleyhull Spire -	142027 139806

Corley from Arbury Hill 117463 feet.

Corley - - - - - Arbury - - - - - *Dun Church Windmill*	10 17 47 18 1 45	Dun Church Windmill	70621 44249
Corley - - - - - Arbury - - - - - *Gazebo on Bardon Hill, Leicestershire*	107 11 9 34 20 2	Gazebo on Bardon Hill	106471 180344
Corley - - - - - Arbury - - - - *Markfield Windmill*	100 41 54 36 37 26	Mzrkfield Windmill -	103373 170270
Corley - - - - Arbury - - - *Newnham Windmill*	2 45 41 101 33 35	Newnham Windmill -	118771 5845

Corley from Broadway 171570 feet.

Broadwzy - - - - Corley - - - - *Building on Breadon Hill*	96 31 27 14 33 9	Building on Breadon Hill	46201 182682

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Epwell from Crouch Hill 29668,8 feet,

Triangles.	Angles observed	Distances of the Stations from the intersected Objects.	
	° ′ ″		Feet.
Epwell	24 43 28	Deddington Steeple	47493
Crouch Hill	124 8 31		24000
Deddington Steeple			
Epwell	22 2 57	Bloxham Spire	31887
Crouch Hill	89 27 20		11971
Bloxham Spire			
Epwell	12 41 39	Aynoe Steeple	60070
Crouch Hill	155 28 33		31802
Aynoe Steeple			
Epwell	12 45 23	Adderbury Spire	43823
Crouch Hill	143 29 30		16265
Adderbury Spire			
Epwell	9 33 29	Farthingo Steeple	64520
Crouch Hill	162 29 20		35605
Farthingo Steeple			

Epwell from Arbury Hill 83098,4 feet.

Triangles.	Angles observed	Distances of the Stations from the intersected Objects.	
Epwell	27 30 1	Round House, Edge Hills	20235
Arbury Hill	8 9 42		65816
Round House, Edge Hills			
Epwell	50 9 8	St. Martin's, Coventry	122636
Arbury Hill	87 15 6		94262
St. Martin's, Coventry			
Epwell	28 31 46	Round House Windmill	18576
Arbury Hill	7 34 6		67364
Round House Windmill, Edge Hills			

Brill from Quainton 40908,6 feet.

Triangles.	Angles observed	Distances of the Stations from the intersected Objects.	
Brill	19 36 52	Wingrove Steeple	75747
Quainton	140 7 47		39665
Wingrove Steeple			
Brill	16 25 48	Hardwick Steeple	55539
Quainton	128 12 5		19989
Hardwick Steeple			

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Triangles.	Angles observed.	Distances of the Stations from the intersected Objects.	
Brill Quainton *Luggersal Steeple*	° ′ ″ 16 42 12 4 24 16	Luggersal Steeple	Feet. 8710 32664
Brill Quainton *Granborough Steeple*	8 30 43 144 20 22	Granborough Steeple	52266 13270
Brill Quainton *Bicester Steeple*	105 7 30 32 10 53	Bicester Steeple	32132 58210
Brill Quainton *Centre of the Great House at Wooton*	17 37 12 9 28 57	House at Wooton	14793 27181

Stow from Broadway 52203,2 feet.

Stow Broadway *Sarsden Chapel*	123 23 50 19 25 13	Sarsden Chapel	28720 72115
Stow Broadway *Walford Spire*	56 10 42 49 34 47	Walford Spire	41295 45063
Stow Broadway *Bourton Chapel*	14 3 44 21 32 40	Bourton Chapel	32926 21786

Stow from Epwell 78938,2 feet.

Stow Epwell *Stow on the Wold Steeple*	60 30 20 6 37 9	Stow on the Wold	9876 74573

Wendover from Brill 92400,7 feet.

Brill Wendover *Pitchcot Windmill*	43 30 12 46 37 4	Pitchcot Windmill	53739 50901

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Triangles.	Angles observed.	Distances of the Stations from the intersected Objects.	Feet.
Brill	24 15 12	Ivinghoe Spire	95663
Wendover	111 33 40		43577
Ivinghoe Spire			
Brill	66 36 4	Padbury Steeple	72943
Wendover	46 32 33		92401
Padbury Steeple (doubtful)			
Brill	46 40 52	Quainton Steeple	39009
Wendover	31 1 48		55056
Quainton Steeple			

Wendover from Quainton 72889,4 feet.

Triangles.	Angles observed.	Distances of the Stations from the intersected Objects.	Feet.
Wendover	34 46 37	Wing Steeple	52487
Quainton	45 9 20		42230
Wing Steeple			
Wendover	44 58 11	Crindon Windmill	66472
Quainton	61 9 59		53626
Crindon Windmill			

Quainton from Bow Brickhill 67490,6 feet.

Triangles.	Angles observed.	Distances of the Stations from the intersected Objects.	Feet.
Quainton	75 15 34	Southern Obelisk	58876
Bow Brickhill	47 19 1		77449
Souther Obelisk, Stow Park, Bucks			
Quainton	75 4 46	Northern Obelisk	61881
Bow Brickhill	49 13 49		78942
Northern Obelisk, Stow Park			

Wendover from Kinsworth 84462 feet.

Triangles.	Angles observed.	Distances of the Stations from the intersected Objects.	Feet.
Kinsworth	69 56 52	Leighton Buzzard	35317
Wendover	31 6 26		64215
Leighton Buzzard Spire			

Kinsworth from Quainton 84996,3 feet.

Triangles.	Angles observed.	Distances of the Stations from the intersected Objects.	Feet.
Kinsworth	17 49 12	Aylesbury Steeple	70886
Quainton	51 5 23		27879
Aylesbury Steeple			

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Bow Brickhill from Lidlington 32035,6 feet.

Triangles.	Angles observed.	Distances of the Stations from the intersected Objects.	Feet.
	° ′ ″		
Bow Brickhill	57 43 21	North Crawley Spire	34968
Lidlington	65 40 39		32444
North Crawley Spire			
Bow Brickhill	45 8 47	Pavenham Spire	77064
Lidlington	112 13 11		59014
Pavenham Spire			
Bow Brickhill	24 15 25	St. Paul's, Bedford	68727
Lidlington	137 19 21		41652
St. Paul's Spire, Bedford			
Bow Brickhill	48 2 42	Sharnbrook Spire	84080
Lidlington	111 8 15		67038
Sharnbrook Spire			
Bow Brickhill	38 42 47	Woburn Market House	12656
Lidlington	19 39 20		23533
Woburn Market House			
Bow Brickhill	5 3 35	Ridgemont Station	21484
Lidlington	10 6 1		10804
Ridgemont Station			
Bow Brickhill	25 51 29	Wootton Spire	46959
Lidlington	116 31 15		22889
Wootton Spire			
Bow Brickhill	36 40 14	Cranfield Spire	29599
Lidlington	64 51 26		19526
Cranfield Spire			

Lillyhoe from Lidlington 49026,1 feet.

Triangles.	Angles observed.	Distances of the Stations from the intersected Objects.	Feet.
Lillyhoe	3 1 25	Pollux Hill Spire	24604
Lidlington	3 2 16		24489
Pollux Hill Spire			
Lillyhoe	23 13 23	Bow Brickhill Steeple	70224
Lidlington	119 15 11		31738
Bow Brickhill Steeple			
Lillyhoe	49 54 3	Colmworth Spire	97617
Lidlington	100 30 33		75944
Colmworth Spire			

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Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
	° ′ ″		Feet.
Lillyhoe Lidlington *Silsoe Spire*	23 57 30 22 4 36	Silsoe Spire	25599 27658
Lillyhoe Lidlington *Flitton Steeple*	11 46 23 17 18 29	Flitton Steeple	30008 20580
Lillyhoe Lidlington *Shillington Steeple*	57 56 38 19 37 7	Shillington Steeple	16857 42549
Lillyhoe Lidlington *Westoning Steeple*	14 35 24 24 29 56	Westoning Steeple	32242 19586
Lillyhoe Lidlington *Wrest Garden Obelisk*	23 40 47 19 18 12	Wrest Garden Obelisk	23770 28880
Lillyhoe Lidlington *St. Neot's Steeple*	63 39 11 88 31 51	St. Neot's Steeple	105026 94147

Kinsworth from Lidlington 61255,3 feet.

Kinsworth Lidlington *Harlington Steeple*	17 4 20 23 39 1	Harlington Steeple	37666 27565
Kinsworth Lidlington *Maulden Steeple*	17 22 11 87 3 13	Maulden Steeple	63165 18882
Kinsworth Lidlington *Millbrook Steeple*	3 53 24 73 16 9	Millbrook Steeple	60167 42622
Kinsworth Lidlington *Streatly Steeple*	36 15 30 33 41 7	Streatly Steeple	36167 38567
Kinsworth Lidlington *Hanslop Spire*	34 29 11 166 4 4	Hanslop Spire	111928 70552

Kinsworth from Bow Brickhill 57668 feet.

Triangles.	Angles observed.	Distances of the Stations from the Intersected Objects.	Feet.
Bow Brickhill Kinsworth *Souldrope Spire*	° ′ ″ 131 31 20 30 17 44	Souldrope Spire	93229 138367
Bow Brickhill Kinsworth *Sauldon Windmill*	91 22 55 28 24 55	Sauldon Windmill	31623 66434
Bow Brickhill Kinsworth *Stewkley Windmill*	70 9 33 33 27 4	Stewkley Windmill	32706 55812
Bow Brickhill Kinsworth *Tharfield Windmill*	61 57 57 93 36 13	Tharfield Windmill	139157 123073
Bow Brickhill Kinsworth *Tottenhoe Station*	4 13 44 14 47 27	Tottenhoe Station	43177 13049
Bow Brickhill Kinsworth *Chalgrave Steeple*	21 55 14 43 21 54	Chalgrave Steeple	43590 23699
Bow Brickhill Kinsworth *Lidlington Windmill*	85 34 3 27 23 29	Lidlington Windmill	28814 62442
Bow Brickhill Kinsworth *Keysoe Spire*	116 45 10 42 6 4	Keysoe Spire	107275 142850

Lillyhoe from Trusler Hill 50673,6 feet.

Lillyhoe Trusler Hill *Knotting Green Elm Tree*	51 56 21 103 29 55	Knotting Green Elm Tree	118536 95981
Lillyhoe Trusler Hill *Sundon Windmill*	36 45 37 27 4 1	Sundon Windmill	25692 33790

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Bow Brickhill from Trusler Hill 20138,7 feet.

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
Bow Brickhill Trusler Hill *Crawley Steeple*	° ′ ″ 25 13 54 50 16 22	Crawley Steeple	15998 8867
Bow Brickhill Trusler Hill *Moulshoe Steeple*	93 18 15 49 17 46	Moulshoe Steeple	25136 33101
Bow Brickhill Trusler Hill *Woburn Steeple*	13 27 17 19 46 14	Woburn Steeple	12432 8552

Bow Brickhill from Lillyhoe 69867 feet.

Bow Brickhill Lillyhoe *Renhold Steeple*	50 57 17 68 43 59	Renhold Steeple	84608 79373
Bow Brickhill Lillyhoe *Ravensden Steeple*	64 55 32 66 41 24	Ravensden Steeple	85825 84646

Kinsworth from Lillyhoe 47278,7 feet.

Kinsworth Lillyhoe *Flitwick Steeple*	43 44 48 71 53 53	Flitwick Steeple	49849 35264

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SECTION SECOND.

Determination of the Latitudes and Longitudes of the Stations on Black Down, in Dorsetshire, Butterton, in Devonshire, and St. Agnes Beacon, in Cornwall.

ART. XVI.—*Calculation of the Distance between Black Down and Dunnose in the Isle of Wight.*

To complete this distance, I shall have recourse to the XXVIth and XXVIIth triangles, published in the Philosophical Transactions of 1795, and LIIId and LIVth of the Trans. for 1797, together with the observations made at Black Down, in the latter year. (See also Pl. XXX. Fig. 1.).

The most eligible method of calculating with these *data*, seems to be that of first finding the *cross-distance* between Black Down and Dean Hill. To do this, we have the angle at Nine Barrow Down, between Black Down and Dean Hill, and the respective distances from the first to the latter stations, together with the newly observed angle between Dunnose and Nine Barrow Down; from which we obtain the angles of a triangle, constituted by Dunnose, Nine Barrow Down, and Black Down.

The distance from Nine Barrow Down to Dean Hill is 166497 feet, and, from the same station to Black Down, the distance is 126782 feet, (see Phil. Trans. for 1795, p. 502, and for 1797, p. 455,) and the angle comprehended by those distances $= 110° 30' 13'',25$. The difference between the horizontal angle and that formed by the chords is $3'',25$, which, substracted from $110° 30' 13'',25$, leaves $110° 30' 10''$: computing with this

angle and the sides spoken of, there results the following triangle, viz.

Nine Barrow Down	-	110° 30′ 10″
Black Down	- -	40 6 54,75
Dean Hill	- - -	29 22 55,75

This, using the side Nine Barrow and Dean Hill, (166497 feet,) gives 240236,7 feet, for the distance between Black Down and Dean Hill.

The angle at Dean Hill, between Nine Barrow Down and Dunnose, is 64° 50′ 19″, (see Phil. Trans. for 1795. p. 501,) and the angle between Black Down and Nine Barrow, as just found, is 29° 22′ 55″,75, which, increased by the proper correction for the difference between the chord and horizontal angles, becomes 29° 22′ 57″,5. The sum of these angles, 94° 13′ 16″,5, is the horizontal angle between Black Down and Dunnose.

The angle at Black Down, between Dunnose and Nine Barrow Down, deduced from observations made in 1797, is found to be 4° 30′ 25″,75: this, subtracted from the angle between Dean Hill and Dunnose, leaves 35° 36′ 29″, for the angle at Black Down; which, corrected for the purpose of reduction to their respective chord angles, become 94° 13′ 11″,5, and 35° 36′ 25″,75, from whence we get the angle at Dunnose = 50° 10′ 22″,75. We have, therefore, the following triangle, viz.

Dean Hill	- - -	94° 13′ 11,5″
Black Down	- -	35 36 25,75
Dunnose	- - -	50 10 22,75

The distance between Dean Hill and Dunnose is 183496,2 feet, (Phil. Trans. for 1795, p. 501,) and that between Black Down and Dean Hill, according to the foregoing computation, is 240236,7 feet: these, applied to the angles of the above triangle,

give 314309,6, and 314305,4 feet, respectively, for the distance between Black Down and Dunnose: wherefore, the mean 314307,5 feet, = 59,528 miles, may be considered as the true distance between those stations.

Direction of the Meridian at Black Down.

On the 18th of April, in the forenoon, the angle between the Pole Star, when at its greatest apparent elongation from the meridian, was observed, and found to be -	104° 19′ 19″,25
And on the 19th, in the afternoon -	98 42 47
Half their sum is the angle between the meridian and Abbotsbury staff - -	101 31 3
On the 20th of April, in the forenoon, the angle between the Pole Star, when at its greatest apparent elongation from the meridian, was observed, and found to be -	104 19 25,25
And on the 19th, in the afternoon -	98 42 35,5
Half their sum is the angle between the meridian and Abbotsbury staff - -	101 31 0,5

Therefore, 101° 31′ 2″ may be taken for the angle between the meridian and Abbotsbury staff.

ART. XVII.—*Latitude and Longitude of Black Down.*

The angle between Dunnose and the Abbotsbury Staff was observed, and found = 164° 26′ 35″25; and the angle between the meridian and the same staff, by double azimuths of the Pole Star, 101° 31′ 2″. Wherefore their sum, subtracted from 360°, leaves 94° 2′ 22″,75, the angle which Dunnose makes with the meridian.

In Fig. 4. Plate XXX. let *Z* be the zenith, B the station on Black Down, and ZBA its meridian; also, let D be Dunnose, and ZD its meridian; likewise, suppose BC to be an arc of a great circle, perpendicular to the meridian at B, and DA another arc of a great circle, perpendicular to the meridian at D, BF and ED being the parallels of latitude at Black Down and Dunnose.

In the spherical triangle BZD, the angles at B and D are given, the first being $94^\circ\ 2'\ 22'',75$, and the second $84^\circ\ 54'\ 53''$; therefore, in the triangle ABD the angle at B is $85^\circ\ 57'\ 36'',75$, and, in the triangle BDC, the angle at $D = 84^\circ\ 54'\ 53''$: hence, the angles of these triangles, when reduced to those formed by the chords, are as follows:

$$\text{In the triangle BDC} \begin{cases} DDC = 84^\circ\ 54'\ 52{,}5'' \\ CDB = 91\quad 2\quad 44{,}75 \\ CBD = \ \ 4\quad 2\quad 22{,}75 \end{cases}$$

$$\text{And in the triangle ABD} \begin{cases} ABD = 85\quad 57\quad 36{,}75 \\ BAD = 88\quad 57\quad 16{,}25 \\ BDA = \ \ 5\quad 5\quad 7 \end{cases}$$

Now the distance between Black Down and Dunnose, BD, has been already found to be 314307,5 feet; therefore, using the above angles with that distance, (after the proper corrections are applied for reducing the horizontal angles to those formed by the chords,) we get,

$$\text{In the triangle BCD} \left\{\begin{matrix} BC = 313128 \\ CD = 21146{,}9 \end{matrix}\right\} \text{feet.}$$

$$\text{And in the triangle ABD} \left\{\begin{matrix} AD = 313581{,}2 \\ AB = 27864{,}5 \end{matrix}\right\} \text{feet.}$$

Again, in the two small triangles formed by the parallels BF and ED, the perpendiculars BC and DA, and the small arcs CF and AE, we have the angles at C and A given, the

first being $91° 2' 45'',75$, and the last $88° 57' 15''$; which angles, however, are augmented by the addition of the differences between the horizontal angles and those formed by the chords, We have therefore,

$$\text{In the triangle BCF} \begin{cases} BCF = 91° \ 2' \ 45,75'' \\ BFC = 88 \ 25 \ 51,5 \\ FBC = \ 0 \ 31 \ 22,75 \end{cases}$$

$$\text{And in the triangle AED} \begin{cases} EAD = 88 \ 57 \ 17 \\ AED = 90 \ 31 \ 21,5 \\ ADE = \ 0 \ 31 \ 21,5 \end{cases}$$

And, using BC and AD, as found above, we get

$$\left.\begin{array}{r} CF = 2859,1 \\ \text{And } EA = 2859,8 \end{array}\right\} \text{feet.}$$

Therefore $FD = DC + CF = 22146,9 + 2859,1 = 25006$ feet. And $BE = BA = EA = 27864,5 - 2859,8 = 25004,7$ feet. The mean, 25005,3 feet, may be considered as very nearly the true distance between the parallels of Black Down and Dunnose. This method is the same as that made use of in the Phil. Trans. for 1795, p. 521, and affords the means of very accurately determining the distance between the parallels of latitude of the two stations, when the angles were observed with precision, and the direction in which the stations lie, is not much removed from east and west.

This small space, 25004,7 feet, corresponds to $4' \ 6'',5$, in which I use 60851 fathoms for the length of a degree of the meridian in $50° \ 41'$. See Phil. Trans. for 1795, p. 537.

Now the latitude of Dunnose is $50° \ 37' \ 7'',3$, and its longitude $1° \ 11' \ 36''$; (Phil. Trans. for 1795, p. 536;) therefore, $50° \ 37' \ 7'' 3 + 4' \ 6'',5 = 50° \ 41' \ 13'',8$, is the latitude of Black Down.

This method of finding the latitude seems to be more correct than by spherical computation; yet, by this latter, nearly the

same conclusion is derived; for, the bearing of Black Down west of Dunnose being 84° 54′ 52″,5, we get the distance of that station from the meridian of the latter = 313072 feet, and from the perpendicular, 27861 feet; which, converted into parts of an arch, according to the lengths of their respective degrees, gives 50° 41′ 14″ for the latitude, and 1° 20′ 46″,4 for the longitude west of Dunnose. According to the troublesome yet ingenious method recommended by M. Sejour, in his *Traité Analytique des Mouvemens apparens des Corps Célestes*, the latitude of Black Down comes out 50° 41′ 13″,9, and the longitude 1° 20′ 45″,75. We may, therefore, admitting the supposition of Dunnose being situated in 50° 37′ 7″,3, safely take 50° 41′ 13″,8 for the latitude, and 2° 32′ 22″,4 for the longitude, of Black Down; that of Dunnose being 1° 11′ 36″ west of the meridian of Greenwich.

Art. xviii. *Calculation of the Distance between the Stations on Black Down, in Dorsetshire, and Rippin Tor, in Devonshire.*

For the calculation of this distance, we must have recourse to the xlviith, xlviiith, xlixth, and lth triangles. (See Philosophical Transactions for 1797, and Plate XXX, Fig. 1 of this Volume.) In the two first, we have the whole angle at Pilsden, between Dumpdon and Black Down = 152° 37′ 27″,25, which, reduced to the angle formed by the chords, becomes 152° 37′ 24″,25. The sides forming this angle, are Dumpdon and Pilsden, Pilsden and Black Down: the distance between the two first stations being 78459,3 feet, and between the two last 79110,7 feet. From these *data*, the distance between Dumpdon and Black Down is found to be 153095,7 feet, the triangle for computation being,

Pilsden - - 152° 37′ 24″,25
Black Down - 13 37 50 ,5
Dumpdon - - 13 44 45 ,25

But this side may be also found, by computing with the whole angle at Charton Common, which angle, when reduced to the plane of the chords, becomes 141° 33′ 53″,75. The two sides are 581012,5 feet, and 103345 feet; which *data* give the following triangle:

Charton - - 141° 33′ 53″,5
Dumpdon - 24 48 39 ,25
Black Down - 13 37 27 ,25; from whence we find the distance from Dumpdon to Black Down = 153094,6 feet. Wherefore, the mean, 153095,2 feet, may be considered to be very nearly the true distance.

In the Lth triangle, (Cawsand Beacon, Dumpdon, and Little Haldon) the angle at Cawsand Beacon is 43° 14′ 21″,25; and in the LIst, (Rippin Tor, Cawsand Beacon, and Little Haldon) the angle at the same station is 25° 30′ 39″,75; their sum is 68° 45′ 1″, and, adding 1″ for the necessary correction, it becomes 68° 45′ 2″. Computing with this angle, and the including sides, (64020,5 and 18334 feet,) we obtain the following triangle:

Rippin Tor - - 90° 34′ 35″
Cawsand Beacon - 68 45 2
Dumpdon - - 20 40 23, which gives the distance from Dumpdon to Cawsand Beacon = 169014 feet.

In the XLIXth triangle, the observed angle at Dumpdon is found to be 86° 39′ 8″5, and, by adding to it the horizontal angle at Dumpdon, between Rippin Tor and Little Haldon, and also that between Black Down and Charton Common, we get 125° 54′ 30″,5, for the horizontal angle between Rippin

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Tor and Cawsand Beacon. To reduce this angle to that formed by the chords, 6″ must be subtracted; therefore, 125° 54′ 24″,5 is the angle for computation. The sides Dumpdon and Rippin Tor, Dumpdon and Black Down, (169014 and 153095,2 feet,) with this angle, give the following triangle:

Rippin Tor	-	25° 36′ 4″,5
Dumpdon	-	125 54 24,5
Black Down	-	28 29 31, which gives the

distance from Rippin Tor to Black Down = 286973,3 feet.

On referring to the observations made in 1797, on Black Down, it will be seen that the angle between Rippin Tor and the staff erected near Abbotsbury, was 3° 8′ 52″,5, and the angle between Pilsden and the same staff 45° 16′ 13″; their difference, 42° 7′ 20″,5, is the angle between Rippin Tor and Pilsden. Now, if the angles of the triangles, five in number, used in finding the distance between Rippin Tor and Black Down have been observed correctly, and the calculations properly made, the computed angle at Blackdown, between those stations, should be, of course, the same; but the angle formed by the chords of the arcs between Blackdown and Pilsden and Dumpdon, has been found = 13° 37′ 50″,5, (which is very nearly the same as the horizontal one,) and the angle between Dumpdon and Rippin Tor = 28° 29′ 31″, which it is also unnecessary to correct: their sum is 42° 7′ 21″,5, the very angle observed. It is not, perhaps, proper to dismiss this consideration, without observing that this agreement affords a strong proof of the excellence of our instrument, as the triangles, from their magnitude and nature, are not so disposed as to favour the comparison.

ART. XIX. *Latitude and Longitude of Rippin Tor.*

The angle at Blackdown, between the staff at Abbotsbury and the meridian, has been found = 101° 31′ 1″,5, nearly, and that between Rippin Tor and the same staff = 3° 8′ 52″,5; therefore, 98° 22′ 8″ is the angle which Rippin Tor makes with the meridian, and this, taken from 180°, leaves 81° 37′ 52″, the bearing of Rippin Tor SW from Black Down.

This angle, with the distance found above, gives 28585,3 feet, for the distance of Rippin Tor from the meridian of Black Down, and 56086,0 feet, for that from its perpendicular; therefore, the latitude is 50° 33′ 59″,1, and the longitude west from Black Down, 1° 13′ 3″,8; consequently, its longitude west of Greenwich is 3° 45′ 26″2.

Direction of the Meridian at Butterton Hill.

On the 6th of May, in the afternoon, the angle between the Pole Star, when at its greatest apparent elongation from the meridian, and the staff on Hemmerdon Ball was observed, and found to be - - - - - -	91° 29′ 13″75
And on the 7th, in the afternoon - -	97 4 14
Half their sum is the angle between the meridian and the staff on Hemmerdon Ball -	94 16 44
Again, on the 7th, in the afternoon, the angle between the Pole Star, when at its greatest apparent elongation from the meridian, and the staff on Hemmerdon Ball was observed, and found to be - - - - - -	91 29 12

Half the sum of this, and the angle observed

in the forenoon of the same day, (97° 4′ 14″) is - - - - - 94° 16′ 43″

Hence, 94° 16′ 44″ may be considered as the true angle between the meridian and the staff on Hemmerdon Ball.

The angle between the station on Rippin Tor and Hemmerdon Ball, is 121° 17′ 7″,75; therefore, 121° 17′ 7″,75 − 94° 16′ 44″ = 27° 0′ 23″,75, is the bearing of Rippin Tor, north-east of Butterton. This angle, with 62951 feet, gives 28585,2 feet, and 56086,6 feet, for the distance of Rippin Tor from the meridian and perpendicular; which, using 61182 and 60847 fathoms, for the lengths of degrees on the meridian and perpendicular, respectively become 4′ 40″,3, and 9′ 13″. Therefore, in the right angled spherical triangle BPT, (Plate XXX, Fig. 2,) in which B is Butterton, P the pole, T Rippin Tor, and R the point where the parallel to the perpendicular cuts the meridian, we have the co-latitude of T, or Rippin Tor, = 39° 26′ 0″,9, and RT = 4′ 40″,3, We have, consequently, cosine 4′ 40″,3 : radius : : cosine 39° 26′ 0,″9 : cosine 39° 26′ 0,″7, the co-latitude of the point R. So PB = PR + RT = 39° 26′ 0″,7 + 9′ 13″ = 39° 35′ 13″,7; therefore, the latitude of Butterton is 50° 24′ 46″,3, and its longitude west from Greenwich, 3° 52′ 47″,5.

Art. xx. *Calculation of the Distance between Hensbarrow and Butterton.*

The most convenient, as well as the most accurate means of computing this distance, will be by referring to the LVIth, LVIIth, and LXIVth triangles, in the series of 1796, where the sum of the observed angles at Carraton Hill is 136° 52′ 43″. The correction for reducing this angle to that formed by the chords, is 4″; therefore, 136° 52′ 39″ is the proper angle for computation.

The distance from Hensbarrow to Carraton Hill, is 100416 feet, and from Butterton to that station 131576 feet. (See Phil. Trans. for 1797, p. 458, 460.) These *data* give the following triangle, viz.

Carraton Hill	- -	136° 52′ 39″
Hensbarrow -	-	24 35 57,5
Butterton -	-	18 31 23,5, which gives

21602 feet, for the distance between Hensbarrow and Butterton Hill.

The angle between Carraton Hill and Rippin Tor was observed in 1796, and found = 101° 3′ 44″,25. (See Phil. Trans. 1797.) The angle between Hensbarrow and Rippin Tor is 119° 35′ 3″,25; therefore, 18° 31′ 19″ is the angle between Hensbarrow and Carraton. The difference between the horizontal and chord angle is 0″,25 nearly; this, added to 18° 31′ 23″,5, gives 18° 31′ 23″,75, which is nearly the same as the observed angle. This agreement proves, that the angles of the triangles connecting Butterton and Hensbarrow have been observed correctly.

ART. XXI. *Latitude and Longitude of Hensbarrow.*

The angle between Hensbarrow and Hemmerdon, (see Observations made at Butterton,) was 1° 52′ 4″,5; therefore, as the angle between the latter and the meridian = 94° 16′ 44″, we get 92° 24′ 39″,5, for the angle which Hensbarrow makes with the same meridian. The distance from Hensbarrow to Butterton, as found above, is 21602 feet; this, with the angle 92° 24′ 39″,5, gives the distance of Hensbarrow from the meridian = 215871 feet, and from the perpendicular 9089 feet; these, converted into parts of degrees, become 35′ 17″,1, and 1′ 29″,62. There-

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fore, the latitude of Hensbarrow is 50° 23′ 3″,3, and its longitude, west of Butterton, 55′ 20″,2 ; consequently, its longitude, west of Greenwich, is 3° 52′ 47″,5 + 55′ 20″,2 = 4° 48′ 7″,7.

ART XXII. *Direction of the Meridian at St. Agnes Beacon.*

On the 22d of May, in the forenoon, the angle between the Pole Star, when at its greatest elongation from the meridian, and the staff near Peranzabulo, was observed, and found to be - - - - -	38° 26′ 1″,5
And on the 22d, in the afternoon -	44 0 33,25
Half their sum is the angle between the meridian and staff - - -	41 13 17,5

The angle between the staff at Peranzabulo and the station Hensbarrow, was also observed at the same station, and found to be 31° 50′ 55″,5 ; wherefore, 41° 13′ 17″,5 + 31° 50′ 55″,5 = 73° 4′ 13″, is the angle between Hensbarrow and St. Agnes Beacon.

ART. XXIII. *To find the Latitude and Longitude of St. Agnes Beacon.*

In Plate XXX. Fig. 3. Let A be the station at St. Agnes, P the pole, H Hensbarrow, and B the point where the parallel to the meridian of St. Agnes cuts that meridian, BHP being a right angled spherical triangle on the earth's surface.

PH has been already found = 39° 36′ 56″,7 ; and, as BH, the distance of Hensbarrow from the meridian, = 92878, and AB, the distance from the perpendicular, = 28271, we get BH = 15′ 10″,9, and AB = 4′ 38″,8 ; which arcs are found by using 61182 and 60845 fathoms, for the length of their respective

degrees. From these *data*, the latitude of the point B is easily derived; for cosine 15′ 10″,9 : radius : : cosine 39° 36′ 56″,7 : cosine 39° 36′ 54″,2, the co-latitude of B; hence 39° 36′ 54″,2 + 4′ 38″,8 = 39° 41′ 33″,0 the co-latitude of A; hence 50° 18′ 27″ is the latitude of St. Agnes. Its longitude, west from Hensbarrow, is also found by a simple proportion; sine 39° 36′ 54″,2 : radius : : sine 15′ 10″,9 : sine 0° 23′ 48″; therefore, 4° 48′ 7″,7 + 0° 23′ 48″ = 5° 11′ 55″,7, is the longitude of St. Agnes, west of Greenwich.

ART. XXIV.—*Remarks.*

I have shewn, with attention to minuteness, the manner in which the latitudes and longitudes of the stations on which directions of meridians have been observed are determined. It now remains to be considered, how far the uncertain state in which we remain, with respect to the figure of the earth, may affect the accuracy of those conclusions.

If the earth were homogeneous, it would necessarily be an ellipsoid; and, were its diameters known, the longitudes and latitudes of places on its surface might be accurately computed, provided their geodetical situations were correctly ascertained, and the latitude of one station in the series of triangles truly determined.

As there is, however, great reason to suppose that the earth is not any regular geometrical figure, from the impossibility of reconciling the results of the various measurements for ascertaining the lengths of degrees of latitude, some uncertainty must remain with respect to our deductions; but there seems to be reasons for supposing the errors, thence resulting, are confined within moderate limits.

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In making computations on a given hypothesis of the earth's figure, the truth of the conclusions, as well as the ease with which they are found, materially depends on the distances of the objects from their respective fixed meridians.

If the difference of longitude approaches nearly to, or exceeds 3°, to compute that longitude, and also the latitude, it is necessary the precise figure should be understood; because the analogy does not hold good, in that case, between the equality of the sums of the angles of spherical and spheroidical triangles on the earth's surface. With regard to latitudes, more particularly when the distances are diminished by means of frequent new directions of meridians, a knowledge of the exact length of a degree of a great circle is not necessary; because the determination of those latitudes, by means of spherical computation, being true as to sense, the cosines of those small arcs will remain the same.

As there cannot be a doubt justly entertained of the latitude of Greenwich being very accurately determined, as particularly set forth by the Astronomer Royal in his reply to M. CASSINI, it is reasonable to suppose, that if any errors do exist in the latitudes of those stations, they can only have arisen from the computations being made with erroneous lengths of degrees on the meridian.

In our former Papers on this subject, we have taken it for granted, that the length of a degree of the meridian at the middle point between Greenwich and Paris, (50° 10',) is 60842 fathoms, (which supposition may be considered just, provided the latitude of Paris, 48° 50' 14", be as near the truth as 51° 28' 40" is to that of Greenwich,) and afterwards added 9 fathoms,

making it 60851, in order to get the length of the degree in 50° 41′; (see Phil. Trans. 1795, p. 537;) these 9 fathoms, however, were not arbitrarily assumed, but computed. If the latitude of Paris be 48° 50′ 15″, (*Conn. des Tems*, 1797-98, p. 373,) the length of the degree will be about 7 fathoms greater, which will make the degree in 50° 41′, 60849 instead of 60842 fathoms.

The latitude of the station on Beachy Head, 50° 44′ 23″,7, was found by using 60861 fathoms for the length of a degree on the meridian in 51° 6′; but, if it be true that 48° 50′ 15″ is the latitude of Paris, the latitude of Beachy Head will be about one-third of a second greater. This seems to be the limit of the probable error in the computed latitude of this station; since its proximity to the meridian of Greenwich, obviates any doubt of the conclusions being affected by any uncertainty respecting the length of the degree of the great circle perpendicular to the meridian.

The latitude of Dunnose was determined by computing the distance between the parallels of that station and Beachy Head; (see Phil. Trans. for 1795, p. 522;) which method is very exact, and preferable to any other, since the small space between the parallels was determined with great accuracy, leaving not a doubt of a greater error than 3 feet, a quantity corresponding to about $\frac{1}{33}$d part of a second. And, since the same method has been adopted to find the difference of latitude between Black Down and Dunnose, it is highly probable that the latitude of the former station is not removed more than $\frac{1}{10}$ths of a second from the true one, that of Beachy Head being supposed $= 50° 44′ 23″,7$.

It would have been fortunate, had the difference of latitude between Black Down and Butterton, and Butterton and St. Agnes Beacon, been determined in the same manner, since the latitudes of all these important stations would, in that case, have been found with evident accuracy; but, whoever has leisure and inclination to go through these calculations, will find that, by means of the directions of meridians at Butterton and St. Agnes Beacon, the latitudes of those stations may be found to within half a second. By this I mean, that, allowing the latitude of Black Down to be $50° 41' 13'',8$, the latitude of Butterton, $50° 24' 46'',3$, will not deviate more than half a second from the truth; and the same may be said with respect to the latitude of St. Agnes, that of Butterton being admitted as correct. Supposing, therefore, the latitude of Greenwich to be $51° 28' 40''$, we may rely on the assurance of the latitude of St. Agnes Beacon being determined within $1\frac{1}{2}''$ of the truth.

With respect to the longitudes of these stations, their accuracy entirely depends on the observations made at Dunnose and Beachy Head, for determining the length of a degree of a great circle perpendicular to the meridian. The truth of the deduction drawn from those observations rests on their accuracy; and it can scarcely be deemed presumptuous to assert, that an error of more than $1''$ cannot have existed in either of the angles. On this account, therefore, I should suppose, that the difference of longitude between those stations, has been found so nearly as to leave no greater error than $1''$. The whole of the operation to which I now allude, was performed with great care; the directions of the meridians having been determined by means of double azimuths of the Pole Star, confirmed by computed azimuths. In returning to the consideration of this sub-

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ject, I do not perceive any source of error likely to affect the conclusions, unless it be that to which all astronomical observations, made with instruments adjusted by plumb-lines or levels, are liable. In determining differences of longitude through these means, the direction in which any lateral attraction must act, to produce *a maximum* of error, is at right angles to the meridian. If the attraction be *in the plane of it*, it is obvious the double azimuth, although the telescope of the theodolite does not move in a vertical, will nevertheless give, almost exactly, the true direction of the meridian.

The high lands about St. Catherine's Light-House, in the Isle of Wight, are about six miles from Dunnose, and nearly west of it; but it does not appear that the effect of their lateral attraction can have produced any sensible error; since it may be shewn, that the plumb-line of the sector at Schehallien would have deviated only a small part of a second from the true vertical, had the sector itself been placed at that distance from the hill. Beachy Head is situated at the eastern extremity of the South Downs; *a defect* of matter towards the east immediately taking place. This circumstance renders the observations liable to some small errors, on account of the superior lateral attraction in the opposite direction; but, notwithstanding it is very probable that an error induced by either of these attractions, is so very small as to render the subject scarcely worth consideration, yet, as both lie *the same way*, it is satisfactory to consider that they mutually tend to correct the errors which may result from either; we may, therefore, safely conclude, that 1° 11′ 36″ is very nearly the true longitude between the station on Beachy Head and that on Dunnose. Under this persuasion, I consider it probable that the longitude of Black

Down cannot err in excess or defect more than 3″; that of Butterton 5″; and that of St. Agnes Beacon 6″.

The latitudes and longitudes of these important stations, brought under one point of view, will be as follows:

	Latitude.	Longitude west from Greenwich. In degrees.	In time.
Black Down -	50° 41′ 13″,8	2° 32′ 22″,4	10′ 9″,5
Butterton Hill -	50 24 46,3	3 52 47,5	15 31,2
St. Agnes Beacon	50 18 27	5 11 55,7	20 47,7

Note. It may probably be expected, that I should determine the directions of the meridians at Black Down, Butterton Hill, and St. Agnes Beacon, by calculation, and afterwards compare them with the observed ones. I have desisted from the measure in the body of the work, and reserved the little I have to say for this note.

If the earth were a perfect sphere, or an ellipsoid of known diameters, the direction of the meridian, at any station not very remotely situated from the parallel of another, might be determined, provided the direction of the meridian at that station were observed, and the value of the arc subtended by the space between them pretty accurately ascertained, and also the latitude of the station, at which the angle is given, nearly obtained.

Thus, if it be required to find the angle at Dunnose, between Beachy Head and the meridian, from the observed angle at the latter station, and the arc between them, we shall have 39° 15′ 36″,3, the co-latitude of Beachy Head, and 55′ 28″,7 for the oblique arc. These *data* (two sides and an included angle) give 1° 26′ 48″,4, for the difference of longitude between Beachy Head and Dunnose, and 81° 56′ 52″,6, for the angle which the meridian at the latter makes with the former station. The difference of longitude found in a rather more correct way, has been heretofore shewn to be 1° 26′ 47″,93, (see Philos. Trans. 1795. p. 523.) and the angle at Dunnose was also shewn to be 81° 56′ 53″, from observation, which may be considered the same with that found by this mode of computation. In all cases in which the *data* were equally correct, no doubt the direction of meridians might be computed, without fear of the results deviating much from the truth; but, if it be required to find the angle at Black Down, from the observed direction of the meridian at Dunnose, a different method must be used. It is, however, less accurate than the former one, and it has been expressly for this reason, that I have not introduced this subject into the account.

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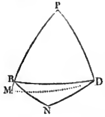

In the adjoining diagram, suppose B, Black Down; D, Dunnose; and, N, Nine Barrow Down: also, let PB, the meridian of Black Down, be prolonged to M, and DM be drawn, PM being = PD. Then we shall have three spherical triangles BPD, BND, and BMD. Now, the angle NBD was found from observations to be 4° 30′ 28″, and BND 172° 27′ 33″,5; these give the angle BDN = 3° 1′ 59″,5, nearly, because the excess of the three angles above 180° is 1″. The observed angle at D, Dunnose, between Nine Barrow Down and the meridian DP, or PDN, was 87° 56′ 53″; therefore, 87° 56′ 53″ — 3° 1′ 59″,5 = 84° 54′ 53″,5, is the angle at D, between the meridian and the station on Black Down.

Now, the difference of longitude between B and D, or the angle at P, has been already found = 1° 20′ 46″,4; and, since BP is very nearly = PD, and BD is small, we shall have rad. : tang. $\frac{1}{2}$P :: cosine DP : cosine BMD = 89° 28′ 47″. But the angle PDB has been found = 84° 54′ 53″,5; therefore, 89° 28′ 47″ — 84° 54′ 53″,5 = 4° 33′ 53,″5, the angle BDM; hence, 180° 0′ 2″ — 94° 2′ 40″,5 = 85° 57′ 21,″5, or MBD; therefore, 94° 2′ 38,″5, or DBP, is the angle at Black Down obtained in this way, which differs nearly 16″ from the observed one, viz. 94° 2′ 22″,75. It is probable, some portion of this arises from defects in the observation made at Dunnose, on the lights fired at Nine Barrow Down: only two lights were seen; and, as the observations differed 5″ from each other, some degree of doubt exists, as to the accuracy of the angle. The angle at Nine Barrow Down, between Black Down and Dunnose, is not absolutely to be depended on for purposes of this kind, although there can be no doubt of its being sufficiently near the truth, for that to which it has been before applied. In the correction of the angles at that station, in our former accounts, we proceeded on the supposition of their being less satisfactory than the other angles of the triangles to which Nine Barrow Down is a common station. For these reasons, I am of opinion the computed angle cannot be applied as a test to the observed one; and it also appears to me, that greater objections lie against similar comparisons between the computed and observed angles at Butterton and St. Agnes; as those stations could not be seen from each other, nor the latter from Black Down. Although the computed directions of the meridians differ some seconds from the observed ones, I am by no means doubtful of the truth of the latter; as the double azimuths of the Pole Star, found from computation, agree very satisfactorily with those which have been used in obtaining the directions of the several meridians.——In finding the value of the oblique arc, or the line which joins Black Down and Dunnose, as used in the first method of computation, I have had recourse to the following *correct* expression, viz. $d = \frac{p\,m}{p + \overline{m - p} \cdot s^2}$; where d is the length of the required degree, p that of the great circle perpendicular to the meridian, m that of a degree of the meridian itself, and s the sine of the angle constituted by the oblique arc and the meridian.

Art. xxv. ***Bearings of the Stations in the Series of 1795 and 1796, from the Parallels to the Meridians of Black Down, Butterton Hill, and St. Agnes Beacon; likewise their Distances from those Meridians, and from their Perpendiculars.***

Meridian of Black Down.

Bearings from the Parallel to the Meridian.			Distances from merid.	Distances from perp.
		° ′ ″	Feet.	Feet.
Bull Barrow -	Black Down	42 2 30 N E	53643,2	59489,7
Mintern -	- - -	10 36 33 N E	10996,8	58709
Pilsden -	- - -	56 14 48 N W	65775,6	43955,4
Charton Common	- -	83 30 3 N W	102681	11697,5
Dumpdon -	Charton Common	45 4 0 N W	143749	52670,9
Rippin Tor -	- -	81 37 52 S W		

Meridian of Butterton.

Rippin Tor -	Butterton	27 0 23 N E	28585,3	56086,6
Furland -	- -	78 37 39 S E	78966,3	15883
Bolt Head -	- -	14 49 48 S E	18551,3	70065,4
Maker Heights -	-	70 36 9 S W	71467,9	25164,3
Kit Hill -	- -	67 12 12 N W	93081,9	39121,7
Carraton Hill -	- -	73 53 22 N W	126408,9	36511,3
Cawsand Beacon -	Rippin Tor	35 35 29 N W	86744,4	108147,5
Little Haldon -	Furland	4 25 2 N E	84571,4	56676,8
Bindown -	- Maker	70 4 48 N W	52926,6	19180,1
Hensbarrow -	- -	87 35 18 S W	92878,0	28271,0

Meridian of St. Agnes Beacon.

Hensbarrow	- St. Agnes Beacon	73 4 13 N E	92877,4	28279,9
Deadman -	- -	72 24 27 S E	97292,5	30849
Karnbonellis	- - -	3 27 27 S W	2741,7	45379,2
Karnminnis	- - -	61 13 58 S W	74168,1	40719
Bodmin	- Hensbarrow	37 30 45 N E	121703,2	65825,8
Lansallos	- Hensbarrow	75 29 51 S E	152945,3	12733,5
St. Burian -	Karnbonellis	67 20 59 S W	94831,5	83807,3
Pertinney -	- Karnminnis	39 25 32 S W	100465,1	72704,4
Sennen -	- Pertinney	40 50 18 S W	113674,4	879868

Art. XXVI. *Latitudes and Longitudes of the Stations in the Series of 1795 and 1796.*

Meridian of Black Down.

Names of Stations.	Latitude.	Longitude from Black Down.	Longitude west of Greenwich. In degrees.	In time.
	° ′ ″	° ′ ″	° ′ ″	m. s.
Bull Barrow - -	50 50 59,5	0 13 53,2 E	2 18 29,2	9 14
Mintern - -	50 50 52,8	0 2 50,8 E	2 29 31,6	9 58,1
Pilsden - - -	50 48 26,9	0 17 0,7 W	2 49 23,1	11 17,5
Charton - -	50 43 6,1	0 26 30,5 W	2 58 52,9	11 55,5
Dumpdon - -	50 49 47,2	0 37 12,1 W	3 39 34,5	14 38,3
Rippin Tor - -	50 33 59,1	1 13 3,8 W	3 45 26,2	15 1,7
Meridian of Butterton Hill.		From merid. of Butterton.		
Furland - -	50 22 7,8	0 23 13,2 E	3 32 34,3	14 10,3
Little Haldon - -	50 34 3,0	0 21 45,6 E	3 31 1,9	14 4,1
Cawsand Beacon -	50 42 31,14	0 2 14,3 W	3 55 1,8	15 40,1
Bolt Head - -	50 13 15,2	0 4 44,5 E	3 48 3,1	15 12,2
Maker - - -	50 20 36,56	0 18 18,2 W	4 11 5,7	16 44,3
Kit Hill - -	50 31 9,4	0 23 55,7 W	4 16 43,2	17 6,9
Carraton Hill - -	50 30 41,6	0 32 29,5 W	4 25 17,0	17 41,1
Bindown - -	50 23 32,9	0 31 53,5 W	4 24 41,0	17 38,7
Hensbarrow - -	50 23 3,3	0 55 20,2 W	4 48 7,7	19 12,5
Meridian of St. Agnes.		From merid. of St. Agnes.		
Lansallos - -	50 20 25,7	0 39 10,3 E	4 32 45,7	18 11,0
Bodmin Down - -	50 29 11,6	0 31 15,9 E	4 40 39,8	18 42,6
Deadman - -	50 13 20,0	0 24 51,3 E	4 47 4,4	19 8,3
Karnbonellis - -	50 10 59,4	0 0 42,0 W	5 12 37,7	20 50,5
Karnminnis - -	50 11 43,8	0 18 56,2 W	5 30 51,9	22 3,5
St. Burian - -	50 4 37,9	0 24 9,2 W	5 36 4,9	22 24,3
Pertinney - -	50 6 27,0	0 25 36,2 W	5 37 31,9	22 30,1
Sennen - - -	50 3 55,6	0 28 56,7 W	5 40 52,4	22 43,5

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ART. XXVII. *Bearings of the intersected Objects, from the Stations in the Series of 1795 and 1796, from the Parallels to the Meridians of Black Down, Butterton Hill, and St. Agnes Beacon; and likewise their Distances from these Meridians.*

Meridian of Black Down.

Bearings from the Parallels to the Meridian.		Distances from merid.	Distances from perp.
At Bull Barrow.	° ′ ″	Feet.	Feet.
Portland Light House -	19 47 16 S E	21581	59985
Noil Windmill - -	10 12 56 N E	72842	166029
Noil Steeple - - - -	21 53 29 N E	86610	141534
Holy Trinity, - Shaftsbury	25 41 52 N E	81081	116506
St. Rumbold's Steeple, Ditto	28 12 51 N E	80486	109522
Maypowder Steeple - -	85 17 11 N W	29526	61479
Stourhead House - - -	0 27 46 N W	52881	153806
Mr. Frampton's Obelisk -	10 3 4 S E	63588	3384
Mere Steeple - - -	6 40 55 N E	63893	146984
Mrs. Thornhill's Obelisk -	22 18 51 N W	40391	91778
Odcomb Spire - -	70 25 0 N W	35474	91194
Milborne Port - - -	38 21 20 N W	20110	101865
At Black Down.			
Puncknoll Flagstaff -	89 9 57 N W	25612	373
Lambert's Castle - -	65 17 36 N W	67269	30950
Lyme Cobb - -	82 21 29 N W	89547	12015
At Pilsden.			
Golden Cape - -	4 44 3 S W	68239	14209
Glastonbury Tor - -	14 19 23 N E	34314	167176
Bridport Beacon - -	8 19 55 S W	72199	91
Lord Rolle's Barn, near Sidmouth	64 34 38 S W	101743	26859
At Dumpdon.			
Naval Flagstaff, Whitlands -	32 45 10 S E	116249	9920
Catherstone Lodge - -	2 29 45 N E	140940	117131
Lord Lisburne's Obelisk -	46 47 34 S W	225502	24119
Sir J. de la Pole's Flagstaff - -	52 3 42 S E	86622	8137
Honiton Steeple - -	12 24 9 S W	146681	39339
St. Mary Ottery Steeple - -	42 21 56 S W	179904	13028
Sir Robert Palk's Tower -	58 56 2 S W	242012	6526

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Meridian of Butterton.

Bearings from the Parallels to the Meridian.		Distances from merid.	Distances from perp.
At Little Haldon.	° ′ ″	Feet.	Feet.
North Bovey - - -	71 44 23 N W	43315	70289
Eastern Karn - - - -	56 27 52 N W	41145	85459
Western Karn - - -	53 12 10 N W	40730	89472
West Down Beacon - - -	63 59 14 N E	126152	76968
Woodley's Summer House - -	83 39 47 S W	29448	50555
Berry Head Flagstaff - -	10 22 16 S E	95740	4350
Brixen Steeple - - -	2 29 4 S E	87435	9331
Ipplepen Steeple - -	22 15 0 S W	68413	17180
Three Barrow Tor - -	68 43 3 S W	8067	27109
Brent Beacon - -	56 11 17 S W	15460	10390
At Butterton.			
Chudleigh Steeple - -	44 4 44 N E	67688	69900
Froward Flagstaff - - -	75 0 28 S E	84342	22587
Start Point Flagstaff - -	39 22 33 S E	56544	68897
Marlborough Steeple - -	16 42 32 S E	18429	61393
Bolt Head Flagstaff - -	14 57 7 S E	18739	70173
Mewstone, highest point - -	52 35 23 S W	49825	38108
Cupola, Hospital, Plymouth -	76 47 30 S W	66891	15699
St. John's Steeple - - -	79 34 44 S W	83991	15447
Saltash Steeple - -	89 37 12 S W	73707	489
Penlee Beacon - - -	64 59 49 S W	69758	32532
Plymstock Steeple - -	73 46 15 S W	49217	14326
Statten Barn - - -	64 43 53 S W	53270	25145
Mount Batton - -	70 50 51 S W	58651	20370
Flagstaff, Plymouth Garrison -	72 51 17 S W	57021	17591
New Church, Plymouth - -	75 25 49 S W	56521	14691
Old Church, Plymouth - -	75 1 56 S W	57505	15374
West Chimney, Governor's House	75 42 15 S W	64497	16435
Flagstaff on Mount Wise - -	75 40 55 S W	65281	16662
Chapel, Plymouth Dock - -	77 33 28 S W	67040	14792
Obelisk, Crimhill Passage, Plymouth	74 7 9 S W	66728	18984
Mount Edgecumbe House - -	72 18 23 S W	65827	21001
Flagstaff, Maker Tower - -	70 53 41 S W	68224	23632
Naval Signal Staff, Maker Tower	70 54 3 S W	68232	23626
Eddystone Light House - -	46 1 27 S W	87190	84127
At Butterton.			
Stonehouse Steeple - -	65 32 37 S W	53078	24140
Puslinch Obelisk - - -	45 17 46 S W	27480	27223
Flagstaff, Rame Head - -	65 3 44 S W	76935	35774
At Rippin Tor.			
Great Haldon - - - -	52 27 0 N E	72023	89479

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Bearings from the Parallels to the Meridian.		Distances from merid.	Distances from perp.
At Maker.	° ′ ″	Feet.	Feet.
Hemmerdon Ball	62 10 37 N E	27722	2077
Brent Tor	5 27 45 N E	62385	69820
Blockhouse Flagstaff	27 51 26 N E	64005	11043
Rame Steeple	20 20 12 S W	74388	33043
Chapel, Dockyard	23 6 50 N E	67042	14795
Flagstaff, Statten Battery	88 9 5 S E	54278	25719
Windmill, Plymouth Dock	29 47 35 N E	65963	15549
At Kit Hill.			
St. Stephen's Steeple	19 29 31 S E	78182	2979
St. Ive Steeple	56 20 4 S W	114213	25047
Callington Steeple	43 0 14 S W	98219	33613
Linkinghorn Steeple	69 8 31 N W	111417	46108
St. Dominic Steeple	27 19 41 N E	89512	46030
South Petherwin Steeple	34 6 18 N W	115216	71807
South Hill	74 57 40 N W	108044	43142
St. Cleer Steeple	74 42 9 S W	133492	27795
At Carraton Hill.			
Cheese Rings	44 0 29 N W	133198	43540
Liskeard Steeple	15 19 39 S W	132155	15546
Landrake Steeple	46 1 2 S E	92463	3750
Duloe Steeple	15 23 3 S W	137923	5336
Menheniot Steeple	11 59 44 S E	121941	15479
Polparrow Flagstaff	20 8 5 S W	138875	2521
Lord Camelford's Obelisk	48 33 15 S W	163992	3324
Boconnock Steeple	44 34 58 S W	158753	3692
Roach Steeple	66 30 33 S W	218318	3434
Roach Rock	65 58 15 S W	217204	3969

Meridian of St. Agnes.

At Lansallos.			
Lanlivery Steeple	56 48 14 N W	119848	34388
Helmen Tor	53 55 17 N W	113818	41243
Mr. Tremaine's Summer House	67 21 40 S W	96548	10787
Gorran Steeple	58 55 59 S W	95877	21647
Flagstaff, Deadman	51 46 44 S W	97059	31278
Gwineas Rocks	53 9 0 S W	106551	22037
At Hensbarrow.			
Hendellion Steeple	2 26 59 N W	89918	97463
Stone, St. Braeg's Down	17 31 12 N W	81868	63145
St. Dennis Steeple	83 6 25 N W	77630	30114
Lansallos Steeple	73 43 28 S E	149787	11656
Gerrans Steeple	26 33 53 S W	55357	46773
St. Michael Carhayes Steeple	9 39 51 S W	84768	19353

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Bearings from the Parallels to the Meridian.		Distances from merid.	Distances from perp.
	° ′ ″	Feet.	Feet.
St. Kivern Steeple	27 6 7 S W	30611	93398
Flagstaff, Blackbead	24 50 36 S W	31214	104917
Windmill, near Fowey	67 2 44 S E	134347	10707
Menabilly House	60 26 48 S E	123516	10899
Old Tower at Polruan	64 44 37 S E	35892	7978
Flagstaff, St. Anthony's Head (D.*)	26 35 45 S W	48664	60038
At the Deadman.			
St. Veep's Steeple	39 4 29 N E	140146	21930
At St. Agnes.			
St. Columb Minor Steeple	44 7 57 N E	40698	41950
Peranzabulo	41 54 34 N E	19354	21563
St. Eval Steeple	37 52 39 N E	50275	64632
Cubert Steeple	42 26 53 N E	23773	25991
Flagstaff, Pendennis Castle	34 19 23 S E	39999	58586
Windmill, St, Mawe's	45 52 9 S E	48079	46642
Karnbre Castle	11 53 47 S W	6480	30760
Illugan Steeple	30 1 2 S W	11865	20537
St. Paul's Steeple	20 21 16 S W	38457	103660
Lord Dunstanville's House	40 33 25 S W	19726	23050
Gwinear Steeple	39 33 34 S W	39578	47911
Cow and Calf	23 7 32 N E	37174	87044
Camborn Steeple	30 16 51 S W	19881	34048
St. Erme Steeple	88 42 22 N E	44657	1009
St. Allen Steeple	85 13 35 N E	36688	3064
Ludguan Steeple	47 39 58 S W	64737	58976
At Karnbonellis.			
Lizard Windmill	1 47 24 S E	573	114785
Grade Steeple	6 41 17 S E	5710	117451
Ruan Major Steeple	3 46 21 S E	1486	109496
St. Hilary Steeple	66 19 33 S W	49009	65664
Mr. Rogers's Tower, near St. Ives	83 43 6 S W	18396	47102
Madern Steeple	76 53 40 S W	81542	63725
Parklough Flagstaff	6 55 11 S W	10735	111240
At Karnminnis.			
St. Buryan Steeple	25 45 25 S W	95205	84320
At St. Buryan.			
Chapel Karnbury	3 25 16 N W	95472	73098
Flagstaff, St. Leven's Point	77 29 40 S W	114449	88158
Sennen Steeple	83 44 37 S W	112202	85712
At Pertinney.			
Stone, LAND'S END	48 5 30 S W	116222	86847

* The letter D is added (as in the former accounts) to those places respecting which any doubts are entertained.

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Art. xxviii. *Latitudes and Longitudes of such intersected Objects, in the Series of 1795 and 1796, as have been referred to the Meridians of Black Down, Butterton Hill, and St. Agnes.*

Names of Objects.	Latitude	Longitude from Black Down.	Longitude west of Greenwich. In degrees.	In time.
	° ′ ″	° ′ ″	° ′ ″	m. s.
Portland Light House -	50 31 22,2	0 5 32,9 E	2 26 49,5	9 47,3
Noil Windmill - -	51 8 29,3	0 18 58,7 E	2 13 23,7	8 53,6
Noil Steeple - -	51 4 27,1	0 22 31,8 E	2 19 50,6	9 19,3
Holy Trinity, - Shaftsbury	51 0 20,7	0 21 3,6 E	2 11 18,8	8 45,3
St. Rumbold's Steeple, Ditto	50 59 11,8	0 20 53,9 E	2 11 28,5	8 45,8
Maypowder Steeple -	50 51 19,7	0 7 38,6 E	2 24 43,8	9 38,9
Stourhead House - -	51 6 29,5	0 13 46,0 E	2 18 36,4	9 14,4
Mr. Frampton's Obelisk -	50 41 46,0	0 16 24,5 E	2 15 57,9	9 3,8
Mere Steeple - -	51 5 21,7	0 16 37,6 E	2 15 44,8	9 2,9
Mrs. Thornhill's Obelisk -	50 56 17,5	0 10 28,6 E	2 21 53,8	9 27,6
Odcomb Spire - -	50 56 12,6	0 9 12,1 W	2 41 34,4	10 46,3
Milborne Port - -	50 57 58,0	0 5 13,1 E	2 27 9,3	9 48,6
Puncknoll Flagstaff -	50 41 17,3	0 6 36,4 W	2 38 58,8	10 35,9
Lambert's Castle - -	50 46 17,7	0 17 23,1 W	2 49 45,5	11 19 .
Lyme Cobb - -	50 43 10,0	0 23 7, W	2 55 29,4	11 41,9
Golden Cape - -	50 43 32,5	0 17 37,2 W	2 49 59,6	11 20
Glastonbury Tor -	51 8 47,7	0 8 56,4 W	2 41 18,8	10 45,2
Bridport Beacon - -	50 41 13,2	0 18 37,6 W	2 50 59,9	11 24
Ld. Rolle's Barn, near Sidmouth	50 45 35,6	0 26 17,2 W	2 58 39,6	11 54,6
Naval Flagstaff, Whitlands	50 42 47,7	0 30 0,4 W	3 2 22,8	12 9,5
Catherstone Lodge - -	51 0 23,0	0 36 36,6 W	3 8 59,0	12 35,9
Lord Lisburne's Obelisk -	50 37 1,3	0 58 5,6 W	3 30 28,1	14 1,9
Sir J. de la Pole's Flagstaff -	50 42 31,9	0 22 21,4 W	2 54 43,8	11 38,9
Honiton Steeple - -	50 47 35,5	0 37 55,7 W	3 10 18,1	12 41,2
St. Mary Ottery Steeple -	50 43 12,9	0 46 26,8 W	3 18 49,2	13 15,3
Sir Robert Palk's Tower -	50 39 52,5	1 2 24,6 W	3 34 47,	14 19,1

Meridian of Butterton Hill.

Names of Objects.	Latitude.	Longitude from Butterton Hill.	Longitude west of Greenwich. In degrees.	In time.
	° ′ ″	° ′ ″	° ′ ″	m s.
North Bovey Steeple (D.) -	50 36 18,7	0 11 9,3 E	3 41 38,2	14 46,5
Eastern Karn - -	50 38 48,4	0 10 36,3 E	3 42 11,2	14 48,7
Western Karn - -	50 39 27,9	0 10 30,1 E	3 42 17,4	14 49,1
West Down Beacon -	50 37 20,5	0 32 30,0 E	3 20 17,5	13 21,1
Woodley's Summer House	50 33 4,5	0 7 34,5 E	3 45 13	15 0,9
Flagstaff, Berry Head, Torbay	50 24 0,7	0 24 33,1 E	3 28 14,4	13 52,9
Brixen Steeple - -	50 23 12	0 22 24,8 E	3 30 22,7	14 1,5
Ipplepen Steeple -	50 27 34,2	0 17 33,8 E	3 35 13,7	14 20,9
Three Barrow Tor - -	50 29 13,5	0 2 13,5 E	3 50 34	15 22,3
Brent Beacon, near Ashburton	50 26 28,6	0 3 58,1 E	3 48 49,4	15 15,3
Chudleigh Steeple -	50 36 14,1	0 17 25,9 E	3 35 21,6	14 21,4
Froward Flagstaff -	50 21 1,4	0 21 36,3 E	3 31 11,2	14 4,7
Flagstaff, Start Point -	50 13 25,9	0 14 26,7 E	3 38 20,8	14 33,4
Marlborough Steeple -	50 14 40,7	0 4 42,5 E	3 48 5,0	15 12,3
Flagstaff, Bolt Head - -	50 13 14,1	0 4 47,2 E	3 48 0,3	15 12
Mewstone, highest point -	50 18 29,7	0 12 45,1 W	4 5 32,6	16 22,1
Cupola of Plymouth Hospital	50 22 10,1	0 17 8,5 W	4 9 56,1	16 39,7
St John's Steeple (D.) -	50 22 11,8	0 21 31,4 W	4 14 18,9	16 57,2
Saltash Steeple - -	50 24 39,8	0 18 54,3 W	4 11 41,8	16 42,8
Penlee Beacon - -	50 19 24	0 17 52,6 W	4 10 40,1	16 42,7
Plymstock Steeple - -	50 22 24,2	0 12 36,8 W	4 5 24,3	16 21,6
Slatten Barn - -	50 20 57,4	0 13 38,6 W	4 6 26,1	16 25,7
Mount Batten - -	50 21 24,3	0 15 1,6 W	4 7 49,1	16 31,2
Flagstaff, Plymouth Garrison	50 21 21,8	0 14 36,5 W	4 7 24,0	16 29,6
New Church, Plymouth -	50 22 20,4	0 14 29,0 W	4 7 16,5	16 29,1
Old Church, Plymouth -	50 22 13,6	0 14 44,1 W	4 7 31,6	16 30,1
Eddystone Light House -	50 10 54,5	0 22 15,4 W	4 15 2,9	17 0,3
West Chimney, Governor's House, Plymouth Dock -	50 22 2,9	0 16 31,6 W	4 9 19,1	16 37,2
Flagstaff, Mount Wise -	50 22 0,7	0 16 43,7 W	4 9 31,2	16 38,1
Chapel, Plymouth Dock -	50 22 19	0 17 10,8 W	4 9 58,3	16 39,9
Obelisk, Crimhill Passage	50 21 37,7	0 17 5,8 W	4 9 53,3	16 39,5
Mount Edgecumbe House	50 21 17,9	0 16 51,8 W	4 9 39,3	16 38,6
Flagstaff, Maker Tower	50 20 51,8	0 17 28,5 W	4 10 16,0	16 41,1
Naval Flagst. near Maker Tow.	50 20 51,9	0 17 28,6 W	4 10 16,1	16 41,1
Stonehouse Steeple - -	50 20 47,4	0 13 35,7 W	4 6 23,2	16 25,5
Puslinch Obelisk - -	50 20 17,5	0 7 2,6 W	3 59 50,1	15 59,5
Rame Head - -	50 18 51,7	0 19 41,5 W	4 12 29,0	16 49,9
Great Haldon - -	50 39 27	0 18 34,2 W	3 34 13,3	14 16,9
Hemmerdon Ball - -	50 21 21,2	0 7 6,5 W	3 59 53,6	15 59,5
Brent Tor - -	50 36 13,4	0 16 33,9 W	4 9 21,4	16 37,4
Flagstaff, Blockhouse, Plymouth	50 22 56,4	0 16 24,4 W	4 9 11,8	16 36,8

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Names of Objects.	Latitude.	Longitude from Butterton Hill.	Longitude west of Greenwich. In degrees.	In time.
	° ′ ″	° ′ ″	° ′ ″	m. s.
Rame Steeple	50 19 18,7	0 37 59,8 W	4 30 47,3	18 3,1
Flagstaff, Statten Battery	50 20 31,8	0 13 54,1 W	4 6 41,6	16 26,8
Windmill, Plymouth Dock	50 22 11,6	0 16 54,2 W	4 9 41,7	16 38,8
St. Stephen's Steeple	50 24 15,1	0 20 3,0 W	4 12 50,5	16 51,3
St. Ive Steeple	50 28 49	0 29 20,2 W	4 22 7,7	17 28,5
Linkinghorn Steeple	50 32 17,3	0 28 39,2 W	4 21 26,7	17 25,8
St. Dominic Steeple (D.)	50 32 17,8	0 23 1,2 W	4 15 48,7	17 3,2
South Petherwin Steeple	50 36 3[illegible],4	0 29 40,4 W	4 22 27,5	17 29,8
South Hill Steeple	50 31 48,3	0 27 46,9 W	4 20 34,4	17 22,3
St. Cleer Steeple	50 29 15	0 34 33,1 W	4 27 20,6	17 49,4
Callington Steeple	50 30 14,9	0 25 14,4 W	4 18 1,9	17 12,1
Cheese Rings	50 31 50,5	0 34 14,9 W	4 27 2,4	17 48,1
Liskeard Steeple	50 27 14,4	0 33 55,5 W	4 26 43,0	17 46,8
Landrake Steeple	50 25 20,7	0 23 43,3 W	4 16 30,8	17 6
Duloe Steeple	50 23 48,0	0 35 21,9 W	4 28 9,4	17 52,6
Menheniot Steeple	50 27 14,5	0 31 18,3 W	4 24 5,8	17 36,4
Polparrow Flagstaff	50 25 5,5	0 35 37,4 W	4 28 24,9	17 53,6
Lord Camelford's Obelisk	50 25 11,1	0 42 4,2 W	4 34 51,7	18 19,4
Boconnock Steeple	50 25 15,3	0 40 43,7 W	4 33 31,2	18 14,1
Roach Rock	50 23 53,4	0 55 41,8 W	4 48 29,4	19 13,9
Roach Steeple	50 23 58,7	0 55 59,1 W	4 48 40,6	19 15,1

Meridian of St. Agnes.

Names of Objects.	Latitude.	Longitude from St. Agnes Beacon.	Longitude west of Greenwich. In degrees.	In time.
	° ′ ″	° ′ ″	° ′ ″	m. s.
Lanlivery Steeple	50 24 1,9	0 30 44,0 E	4 41 11,7	18 44,8
Helmen Tor	50 25 9,9	0 29 11,9 E	4 42 43,8	18 50,9
Mr. Tremaine's Summer House	50 16 37,8	0 24 41,6 E	4 47 14,1	19 8,9
Gorran Steeple	50 14 50,8	0 24 30,4 E	4 47 25,3	19 9,6
Flagstaff, Deadman	50 13 15,8	0 24 47,7 E	4 47 8,0	19 8,5
Gwineas Rocks	50 14 46,3	0 27 14,1 E	4 44 41,6	18 58,8
Hendellion Steeple	50 34 25,6	0 23 8,5 E	4 48 47,2	19 15,1
Stone, St. Braeg's Down	50 28 47,6	0 21 1,7 E	4 50 54,0	19 23,6
St. Dennis Steeple	50 23 22,1	0 19 54,1 E	4 52 1,6	19 28,1
St. Michael Carhayes Steeple	50 15 14,0	0 21 40,2 E	4 50 15,5	19 21
St. Kevern Steeple	50 3 5,6	0 7 47,5 E	5 4 8,2	20 16,5
Flagstaff, Blackhead	50 1 12,1	0 7 56,4 E	5 3 59,3	20 15,9
Windmill, near Fowey	50 20 7,2	0 34 24,2 E	4 37 31,5	18 30,1
Menabilly House	50 20 9,9	0 31 37,8 E	4 40 17,9	18 4,11
Old Tower at Polruan	50 1[illegible] 40,2	0 34 47,7 E	4 37 8,0	18 28,5
Flagstaff, St. Anthony's Head	50 8 34,2	0 12 24,7 E	4 59 31,0	19 58,1
St. Veep's Steeple	50 21 57,5	0 35 54,7 E	4 36 1,0	18 24,1
St. Columb Minor Steeple	50 25 20,1	0 10 26,4 E	5 1 29,3	20 5,9
Peranzabulo	50 21 59,4	0 4 57,6 E	5 6 58,2	20 27,9

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Names of Objects.	Latitude.	Longitude from St. Agnes Beacon.	Longitude west of Greenwich. in degrees.	In time.
	° ′ ″	° ′ ″	° ′ ″	m. s.
St. Eval Steeple -	50 29 3,5	0 12 54,9 E	4 59 0,8	19 56
Cubert Steeple - -	50 22 43,0	0 6 5,6 E	5 5 50,1	20 23,3
Flagstaff, Pendennis Castle	50 8 48,7	0 10 12,1 E	5 1 43,6	20 6,9
Windmill, St. Mawes -	50 10 46,3	0 12 16,3 E	4 59 39,4	19 58,6
Karnbre Castle - -	50 13 23,6	0 1 39,3 W	5 13 35,0	20 54,3
Illugan Steeple -	50 15 4,4	0 3 1,9 W	5 14 57,6	20 59,8
St. Paul's Steeple -	50 1 24,3	0 9 47,0 W	5 21 42,7	21 26,8
Lord Dunstanville's House	50 14 39,4	0 5 2,5 W	5 16 58,2	21 7,8
Lansallos Steeple -	50 20 15,3	0 38 16,2 E	4 33 39,5	18 14,6
Gerrans Steeple -	50 10 44,8	0 14 7,7 E	4 57 48,0	19 51,2
Gwinear Steeple - -	50 10 34,	0 10 6,0 W	5 22 1,7	21 28,1
Cow and Calf - -	50 32 44,8	0 9 33,7 E	5 2 22,0	20 9,5
Camborn Steeple -	50 12 51,0	0 5 4,7 W	5 17 0,4	21 8
St. Erme Steeple -	50 18 36,3	0 11 25,7 E	5 0 30,0	20 2
St. Allen Steeple - -	50 18 56,8	0 9 23,6 E	5 2 32,1	20 10,1
Ludguan Steeple -	50 8 44,1	0 16 30,7 W	5 28 26,4	21 53,8
Windmill, Lizard -	49 59 35,1	0 0 8,7 E	5 12 4,4	20 48,3
Grade Steeple - -	49 59 8,8	0 1 27,1 E	5 10 28,6	20 41,9
Ruan Major Steeple -	50 0 27,2	0 0 22,6 E	5 11 29,1	20 45,9
St. Hilary Steeple -	50 7 38,7	0 12 29,7 W	5 24 25,4	21 37,7
Mr. Rogers's Tower -	50 10 42,4	0 4 41,7 W	5 16 37,4	21 6,5
Madern Steeple - -	50 7 56,6	0 20 47,5 W	5 32 43,2	22 10,9
Park Lough Flagstaff	50 0 9,9	0 2 43,8 W	5 14 39,5	20 58,6
Lizard Flagstaff -	49 57 55,8	0 0 38,1 E	5 11 17,7	20 45,2
St. Buryan Steeple -	50 4 32,8	0 24 14,8 W	5 36 10,5	22 24,7
Karnbury Chapel -	50 6 23,5	0 24 19,8 W	5 36 15,5	22 25
St. Leven's Point, Flagstaff	50 3 53,8	0 29 8,5 W	5 41 4,2	22 44,3
Sennen Steeple - -	50 4 18,0	0 28 36,6 W	5 40 29,9	22 41,9
Stone, LAND'S END -	50 4 6,6	0 29 35,8 W	5 41 31,5	22 46,1

Notwithstanding almost the whole of the above latitudes and longitudes belong to objects near the sea coast, yet I have distinguised those which are actually upon it, from those more remotely situated, by *Italics*.

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ART. XXIX. *Bearings of the Stations in the Series of* 1797 *and* 1798, *from the Parallels to the Meridians of Black Down, Butterton Hill, and St. Agnes Beacon; and likewise their Distances from those Meridians*

Meridian of Black Down.

Names of the Stations.		Bearings.	Distances from merid.	Distances from perp.
		° ′ ″	Feet.	Feet
Pilsden Ash Beacon	Moor Lynch	2 33 59 NW 59 52 59 NW	71070	162067
Mintern Moor Lynch	Ash Beacon	5 17 18 NW 59 53 1 SE	5544	117624
Bull Barrow Ash Beacon	Long Knoll	1 2 34 NE 46 45 33 NE	55557	164653
Pilsden Moor Lynch	Dundon	12 40 33 NE 59 17 35 SE	42964	145377
Moor Lynch Ash Beacon	Mendip	66 3 36 NE 3 23 8 NW	1021	194072
Long Knoll Wingreen	Beacon Hill	82 28 4 NE 50 16 22 NW	189665	182386
Long Knoll Mendip	Westbury	39 44 34 NE 80 32 31 NE	92715	209344
Westbury Dundry	Farley Down	35 44 37 NW 88 51 23 SE	57752	257920
Mendip Farley Down	Dundry	18 59 1 NW 88 51 22 NW	21488	259503
Mendip Dundry	Lansdown	22 4 57 NE 77 26 41 NE	32440	271514

Meridian of Butterton Hill.

Carraton Hill Kit Hill	St. Stephen's	15 15 47 NE 21 46 9 NW	112457	87635
Carraton Hill St. Stephen's	Black Down	64 12 55 NE 76 2 26 SE	51797	72555

Meridian of St. Agnes Beacon.

St. Agnes Beacon Hensbarrow	Trevose Head	25 54 12 NE 39 49 34 NW	42858	88250
Trevose Head Bodmin Down	Cadon Barrow	63 18 48 NE 2 11 52 NW	119364	126702
Bodmin Down Cadon Barrow	Brown Willy	28 46 20 NE 46 1 42 SE	142745	104145

ART. XXX. *Bearings of the Stations in the Series of 1799, from the Parallels to the Meridians of Dunnose and Greenwich; and likewise their Distances from those Meridians.*

Meridian of Dunnose.

Names of the Stations.		Bearings.	Distances from merid.	Distances from perp.
		° ′ ″	Feet.	Feet.
Highclere -	Bagshot Heath -	81 40 58 NE	108275	274173
	Nuffield - -	35 30 40 NE	36747	351480
	White Horse Hill -	27 47 37 NW	83796	349533
White Horse Hill	Stow on the Wold	14 29 27 NW	114915	469942
	Brill - -	50 16 17 NE	28955	443235
	Shotover Hill -	53 30 7 NE	3063	413801
	Scutchamfly -	84 25 51 SE	32776	344558
	Whiteham Hill -	36 30 13 NE	31054	420801
Stow on the Wold	Broadway - -	33 3 55 NW	143396	513693
	Epwell - -	39 34 55 NE	64617	530781
Shotover Hill -	Cumner Hill -	76 58 3 SW	25416	407209
Epwell - -	Corley Hill -	6 39 56 NW	81312	673637
	Arbury Hill -	48 5 23 NE	2776	586288
Brill - -	Crouch Hill -	39 20 49 NW	36102	522584
	Quainton - -	61 40 13 NE	64963	462648

Meridian of Greenwich.

Nuffield -	Wendover -	44 48 19 NE	174338	100986
Brill - -		65 49 3 SE		
Brill - -	Bow Brickhill	56 46 9 NE	151413	190493
Arbury Hill -		54 50 52 SE		
Brill - -	Kinsworth -	85 8 30 NE	120910	141562
Bow Brickhill -		31 55 51 SE		
Bow Brickhill -	Lillyhoe -	74 6 27 SE	84215	171367
Kinsworth -		50 54 40 NE		
Bow Brickhill -	Lidlington -	67 24 37 NE	121834	202802
Lillyhoe -		50 6 55 NW		
Bow Brickhill -	Trusler Hill -	89 1 15 SE	131278	190151
Lillyhoe -		68 14 71 NW		

ART. XXXI. *Latitudes and Longitudes of the Stations in the Series of 1797 and 1798, referred to the Meridians of Black Down, Butterton Hill, and St. Agnes Beacon.*

Meridian of Black Down.

Names of the Stations.	Latitude.	Longitude from Black Down.	Longitude west of Greenwich. In degrees.	In time.
	° ′ ″	° ′ ″	° ′ ″	m. s.
Moor Lynch	51 7 50,2	0 18 30,6 W	2 50 53	11 23,5
Ash Beacon	51 0 33,5	0 1 26,4 E	2 30 56	10 3,7
Long Knoll	51 8 16,2	0 14 28,3 E	2 17 54,1	9 11,6
Dundon	51 5 6,5	0 11 10,7 W	2 43 33,1	10 54,2
Mendip	51 13 7,2	0 0 15,9 E	2 32 6,5	10 8,4
Beacon Hill	51 11 1,6	0 49 20,6 E	1 43 1,8	6 52,1
Westbury	51 15 35,3	0 24 13 E	2 8 9,4	8 32,6
Farley Down	51 23 35,7	0 15 7,6 E	2 17 14,8	9 8,9
Dundry	51 23 52,2	0 5 37,7 W	2 38 0,1	10 32,0
Lansdown	51 27 50,4	0 8 30,6 E	2 23 51,8	9 35,4

Meridian of Butterton Hill.

Names of the Stations.	Latitude.	Longitude from Butterton Hill.	Longitude west of Greenwich. In degrees.	In time.
	° ′ ″	° ′ ″	° ′ ″	m. s.
St. Stephen's	50 39 6,7	0 28 59,6 W	4 21 47,1	17 27,1
Black Down	50 36 40,9	0 13 20,5 W	4 6 8,0	16 24,5

Meridian of St. Agnes Beacon.

Names of the Stations.	Latitude.	Longitude from St. Agnes Beacon.	Longitude west of Greenwich. In degrees.	In time.
	° ′ ″	° ′ ″	° ′ ″	m. s.
Trevose Head	50 32 56,5	0 11 1,5 E	5 0 54,2	20 3,6
Cadon Barrow	50 39 12,1	0 30 46,5 E	4 41 9,2	18 44,6
Brown Willy	50 35 27,9	0 36 45,3 E	4 35 10,4	18 20,6

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ART. XXXII. *Latitudes and Longitudes of the Stations in the Series of 1799, referred to the Meridians of Dunnose and Greenwich.*

Meridian of Dunnose.

Names of the Stations.	Latitude.	Longitude from Dunnose.	Longitude west of Greenwich. In degrees.	In time.
	° ′ ″	° ′ ″	° ′ ″	m. s.
Nuffield	51 34 52,2	0 9 39,9 E	1 1 56,1	4 7,7
White Horse Hill	51 34 31,6	0 22 1,7 W	1 33 37,7	6 14,5
Stow on the Wold	51 54 16,3	0 30 26,7 W	1 42 2,4	6 48,1
Broadway	52 1 25,6	0 38 5,3 W	1 49 41,3	7 18,7
Brill	51 49 56,6	0 7 39,4 E	1 3 56,6	4 15,7
Scutchamfly	51 33 44,1	0 8 37 W	1 20 13,0	5 20,8
Shotover Hill	51 45 6,7	0 0 48,5 E	1 10 47,5	4 43,1
Whiteham Hill	51 46 15,4	0 8 12,1 W	1 19 48,1	5 19,2
Cumner Hill	51 44 1,5	0 6 42,4 W	1 18 18,4	5 13,2
Epwell	52 4 19,8	0 17 10,8 W	1 28 46,8	5 55,1
Corley Hill	51 50 28,3	0 9 39,9 W	1 21 15,9	5 25,0
Arbury Hill	52 13 26,6	0 0 44,4 W	1 12 20,4	4 49,3
Crouch Hill	52 2 58,7	0 9 35,6 W	1 21 11,6	5 24,7
Quainton	51 53 7,2	0 17 12,1 E	0 54 23,9	3 37,6

Meridian of Greenwich.

Names of the Stations.	Latitude.	Longitude west of Greenwich. In degrees.	In time.
	° ′ ″	° ′ ″	m. s.
Wendover	51 45 6,4	0 46 1,4	3 4,1
Bow Brickhill	51 59 50,5	0 40 1,2	2 44,1
Kinsworth	51 51 50,8	0 31 59,9	2 7,9
Lillyhoe	51 56 46,5	0 22 19,5	1 29,3
Lidlington	52 1 54,0	0 32 21,7	2 9,4
Trusler Hill	51 59 48,0	0 34 50,5	2 19,3

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ART. XXXIII. *Bearings of intersected Objects, from the Stations in the Series of 1797 and 1798, from the Parallels to the Meridians of Black Down, Butterton Hill, and St. Agnes Beacon; and likewise their Distances from those Meridians.*

Meridian of Black Down.

Bearings from the Parallels to the Meridian.		Distances from merid.	Distances from perp.
At Moor Lynch.	° ′ ″	Feet.	Feet.
Walton Windmill	75 12 31 S E	51340	156858
Westonzoyland Steeple	63 42 36 S W	46928	154235
Middlezoy Steeple	31 48 21 S W	79339	148733
Chedzoy Steeple	85 18 45 N W	90459	163658
Higham Windmill	29 57 17 S E	58858	140880
Higham Steeple	22 51 39 S E	62691	142196
Bridgewater Spire	88 39 25 S W	104717	161280
Somerton Steeple	47 4 54 S E	41197	134292
Burton Pynsent Obelisk	10 35 4 S W	78428	122688
At Dundry.			
Puckle Steeple	55 19 25 N E	26010	292363
Westleigh Steeple	46 49 23 N E	23610	301818
Bristol Cathedral	26 7 30 N E	11836	279184
Redcliff Steeple	33 8 32 N E	9407	278007
Long Aston	0 51 38 N W	21696	273385
Clifden Windmill	9 52 50 N E	19281	272172
Blaze Castle	1 49 16 N E	20268	297874
Penpole Park Gazebo	11 43 37 N W	28680	294155
Duke of Beaufort's House, Stoke	32 31 51 N E	651	294212
Durham Steeple	63 28 33 N E	38049	289219
Knowle Steeple	13 41 30 N E	8112	314410
Mangotsfield Steeple	47 44 31 N E	13923	291677
Winterbown Steeple	31 14 10 N E	7056	300569
Harfield Steeple	20 11 9 N E	93478	292526
Leigh on Mendip	33 59 55 S E	21483	195794
Dundry Steeple	71 23 20 S W	22831	259052
At Long Knoll.			
Doulting Spire	68 59 51 N W	9544	182322
Frome Steeple	5 20 25 N W	52415	198272
At Farley Down.			
Devizes Steeple	79 51 30 S E	129342	245113
Cold Aston Steeple	33 43 21 N W	44362	277983

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Meridian of Butterton Hill.

Bearings from the Parallels to the Meridian.		Distances from merid.	Distances from perp.
At Furland.	° ′ ″	Feet.	Feet.
Hope's Nose	23 7 55 N E	93759	18745
At St. Stephen's.			
Werrington Steeple	29 37 23 N E	109839	92242
Boyton Steeple	0 55 35 N W	112767	106733
St. Stephen's Steeple	45 55 4 S E	110738	85968
North Petherwin Steeple	49 15 49 N W	125044	98473
At Carraton Hill.			
Stokeclimsland Steeple	65 56 2 N E	96381	49922
Launceston Steeple	21 26 54 N E	108267	82689
Launceston Chapel	21 14 13 N E	108513	82561

Meridian of St. Agnes Beacon.

At Bodmin.			
St. Minvern Steeple	58 18 36 N W	79549	91845
St. Minvern Windmill	61 51 46 N W	90966	82260
At Trevose Head.			
St. Isey Steeple	61 2 12 S E	68456	74082
St. Merian Steeple	57 59 32 S E	52096	82476

ART. XXXIV. *Bearings of intersected Objects, from the Stations in the Series of* 1799, *from the Parallels to the Meridians of Dunnose and Greenwich; and likewise their Distances from those Meridians.*

Meridian of Dunnose.

At Epwell.			
Warwick Steeple	16 25 48 N W	87242	607508
St. Martin's, Coventry	2 3 42 N W	69028	653327
Soleyhul Spire	31 8 35 N W	128826	654971
At Arbury Hill.			
Dunchurch Windmill	23 55 48 N W	20724	626734
Breadon Hill, Summer House	7 37 31 N W	26706	765038

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Bearings from the Parallels to the Meridian.		Distances from merid.	Distances from perp.
	° ′ ″	Feet.	Feet.
Markfield Windmill -	5 20 7 N W	18608	755819
Newnham Windmill - - -	59 36 2 N E	2261	589244
At Corley Hill.			
Gazebo, Breadon Hill - -	35 45 58 S W	188086	525408
At Crouch Hill.			
Deddington Steeple -	18 6 0 S E	28646	499771
Bloxham Spire - -	16 35 11 S W	39519	511110
Aynoe Steeple -	49 26 2 S E	11944	501902
Adderbury Spire - - -	37 26 59 S E	26213	509671
Farthingo Steeple - - -	56 26 49 S E	6431	502904
At Arbury Hill.			
Round House, Edge Hills -	56 15 5 S W	57501	549724
Windmill, near the Round House	55 39 29 S W	58398	548286
At Brill.			
Wingrove Steeple - -	81 17 5 N E	103826	454713
Hardwick Steeple - - -	78 6 1 N E	83299	454687
Luggersal Steeple - -	44 56 1 N E	35106	419401
Granborough Steeple - -	53 9 30 N E	70782	474574
Bicester Steeple - - -	43 27 16 N W	6854	466560
Marq. Buckingham's House, Wooton	79 17 25 N E	43490	445984
Islip Steeple - - -	84 26 3 S W	8944	439540
Woodstock Steeple -	85 25 45 N W	35563	448393
Kidlington Spire - -	88 29 39 S W	18401	441989
Witchwood Beacon -	89 11 34 S W	76971	444726
At Whitehorse Hill.			
Abingdon Spire - -	62 38 18 N E	19054	383037
Wallingford Steeple - -	84 54 39 N E	17497	358560
Great Coxwell Windmill - -	25 45 11 NW	96959	376819
Drayton Steeple - -	67 28 0 N E	24691	374055
Highworth Steeple - -	57 49 58 N W	116343	370003
Witney Spire - - -	14 14 57 N E	64787	424380
Bampton Steeple - -	4 36 29 N E	79056	408334
Radley Steeple - - -	61 25 12 N E	12123	388578
Buckland Steeple - - -	20 8 12 N E	69616	388204
At Stow.			
Stow on the Wold Steeple -	20 55 25 NW	118442	479166
At Broadway.			
Sarsden Chapel - - -	52 29 8 S E	86195	469777
Bourton Chapel - - -	54 36 35 S E	125636	501076
Walford Spire - - -	82 38 42 S E	98704	507924

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Meridian of Greenwich.

Bearings from the Parallels to the Meridian.		Distances from merid.	Distances from perp.
At Wendover.	° ′ ″	Feet.	Feet.
Pitchcot Windmill	19 11 59 N W	191077	149055
Ivinghoe Spire	45 44 37 N E	143127	131397
Quainton Steeple	34 47 15 N W	205750	146203
Leighton Buzzard Spire	21 41 12 N E	150616	160663
At Quainton.			
Southern Obelisk, Stow Park	22 1 36 N W	227554	204673
Northern Obelisk, ditto	21 50 48 N W	228505	207532
At Kinsworth.			
Aylesbury Spire	77 56 58 S W	190234	126763
Maulden Steeple	16 30 28 N E	102962	202124
Harlington Steeple	16 12 37 N E	110395	177730
Millbrook Steeple	3 1 41 N E	117732	201645
Stretley Steeple	35 23 47 N E	99961	171044
Szuldon Windmill	60 20 46 N W	178643	174431
At Bow Brickhill.			
Hanslope Spire	38 58 48 N W	185668	232843
North Crawley Steeple	9 41 15 N E	145529	224961
Pavenham Spire	22 15 49 N E	122215	261812
St. Paul's Spire, Bedford	43 9 11 N E	104408	240631
Sharnbrook Spire	19 21 54 N E	123533	269816
Woburn Market-House	73 52 37 S E	139255	186978
Ridgemont Station	72 28 11 N E	130927	196964
Wootton Spire	41 33 7 N E	120265	225635
Cranfield Spire	30 44 22 N E	136284	215933
Husborne Crawley Steeple	65 44 51 N E	136827	197064
Woburn Steeple	75 33 58 S E	139373	187394
Souldrope Spire	16 32 49 N E	124861	279861
Windmill near Tharfield	86 6 12 N E	12577	199950
Tottenhoe Station	27 42 7 S E	130412	150494
Chalgrave Steeple	53 51 5 S E	116215	164780
Keysoe Spire	31 17 59 N E	95682	282155
Moulshoe Steeple	2 19 30 N W	152432	215608
Renhold Spire	44 56 16 N E	91651	250385
Lidlington Windmill	62 30 6 N E	125855	203797
At Lillyhoe.			
Knotting-Green Elm Tree	16 17 56 N W	117482	285139
Ravensden Steeple	7 25 2 N W	95142	255304
Bow Brickhill Steeple	73 20 18 N W	151490	191501

Bearings from the Parallels to the Meridian.		Distances from merid.	Distances from perp.
	° ′ ″	Feet.	Feet.
Colmworth Spire - -	0 12 52 N W	84580	268984
Sundon Windmill - -	75 0 6 S W	109032	164718
Silsoe Steeple - -	26 9 25 N W	95501	194345
Flitton Steeple - -	38 20 32 N W	102831	194903
Shillington Steeple -	7 49 43 N E	81919	188066
Westoning Steeple - -	64 42 19 N W	113366	185143
Wrest-Garden Obelisk -	26 26 8 N W	94797	192652
Flitwick Steeple - -	57 11 27 N W	114694	191016
Ampthill Steeple - -	39 6 3 N W	109957	203041
St. Neot's Steeple - -	13 32 16 N E	59630	273475
Pollux Hill Steeple - -	47 5 30 N W	102236	188118

ART. XXXV. *Latitudes and Longitudes of such Places, in the Series of* 1797 *and* 1798, *as have been referred to the Meridians of Black Down, Butterton Hill, and St. Agnes Beacon.*

Meridian of Black Down.

Names of the Objects.	Latitude.	Longitude from Black Down.	Longitude west of Greenwich. In degrees.	In time.
	° ′ ″	° ′ ″	° ′ ″	m. s.
Walton Windmill -	51 6 59.5	0 13 22,1 W	2 45 44.5	11 2,9
Westonzoyland Steeple -	51 6 33,8	0 12 12,9 W	2 44 35.3	10 58,3
Middlezoy Steeple -	51 5 38,3	0 20 38,8 W	2 53 1,2	11 32,1
Chedzoy Steeple - -	51 8 5,1	0 23 33,7 W	2 55 56,1	11 43.7
Higham Windmill -	51 4 21,8	0 15 18,6 W	2 47 41,0	11 10,7
Higham Steeple -	51 4 34,6	0 16 18,5 W	2 48 40,9	11 14,7
Bridgewater Spire -	51 7 40,7	0 27 16,3 W	2 59 38,7	11 58,6
Somerton Steeple -	51 3 17,3	0 10 42,7 W	2 43 5,1	10 52.3
Burton Pynsent Obelisk -	51 1 21,6	0 20 22,7 W	2 52 45,1	11 31
Westleigh Steeple -	51 30 49,4	0 6 12,0 E	2 26 10,4	9 44,7
Bristol Cathedral -	51 27 6,3	0 3 6,2 W	2 35 28,6	10 21,9
Redcliff Steeple - -	51 26 54,8	0 2 28,0 W	2 34 50,4	10 19,3
Long Aston - -	51 26 9,1	0 5 41,3 W	2 38 3,7	10 32,2
Clifden Windmill -	51 25 57,2	0 5 3,3 W	2 37 25,7	10 29,7
Blaze Castle - -	51 30 10,4	0 5 19,3 W	2 37 41,7	10 30,8
Penpole Gazebo -	51 29 33,7	0 7 31,7 W	2 39 54.1	10 39,6
Duke of Beaufort's House, Stoke	51 29 34,5	0 0 10,2 E	2 32 22,2	10 8,8
Durham Steeple - -	51 28 44,8	0 9 59,0 E	2 22 23,4	9 29,5
Knowle Steeple - -	51 32 53,7	0 2 7,9 W	2 34 30,3	10 18
Mangotsfield Steeple -	51 29 9,5	0 3 39,2 E	2 28 43,2	9 54,8
Winterbown Steeple -	51 31 36,4	0 1 51,2 E	2 30 31,2	10 2,1
Harfield Steeple - -	51 29 15,3	0 24 32,2 W	2 56 54,6	11 47,6
Leigh Steeple on Mendip	51 13 24.	0 5 36,3 E	2 26 46,1	9 47,1
Dundry Steeple -	51 23 47,7	0 5 58,8 W	2 38 21,2	10 33,4

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Names of the Objects.	Latitude.	Longitude from Black Down.	Longitude west of Greenwich. In degrees.	In time.
	° ′ ″	° ′ ″	° ′ ″	m. s.
Doulting Spire - -	51 11 11,4	0 2 29,3 E	2 29 53,1	9 59,5
Devizes Steeple -	51 21 25,5	0 33 51,2 E	2 58 31,2	11 54,1
Frome Steeple - -	51 13 47,9	0 13 40,8 E	2 18 41,6	9 14,7
Cold Aston - -	51 26 53,9	0 11 38,0 E	2 20 44,4	9 24,9
Puckle Steeple -	51 29 16,2	0 6 49,6 E	2 25 32,8	9 42,2

Meridian of Butterton Hill.

Names of Objects.	Latitude.	Longitude from Butterton Hill.	Longitude west of Greenwich. In degrees.	In time.
	° ′ ″	° ′ ″	° ′ ″	m. s.
Hope's Nose, Torbay -	50 27 48,5	0 26 4,4 E	3 26 43,1	13 46,9
Werrington Steeple	50 39 52,2	0 28 19,4 W	4 21 6,9	17 24,4
Boyton Steeple - -	50 42 14,9	0 29 6,1 W	4 21 53,6	17 27,5
North Petherwin -	50 40 52,5	0 32 15,3 W	4 25 2,8	17 40,2
St. Stephen's Steeple -	50 38 50,3	0 28 32,6 W	4 21 20,1	17 25,3
Stokeclimsland Steeple -	50 32 55,8	0 24 47,5 W	4 17 35,0	17 10,3
Launceston Steeple -	50 38 18,1	0 27 54,1 W	4 20 41,6	17 22,7
Launceston Castle -	50 38 16,8	0 27 57,9 W	4 20 45,4	17 23

Meridian of St. Agnes Beacon.

Names of Objects.	Latitude.	Longitude from St. Agnes Beacon.	Longitude west of Greenwich. In degrees.	In time.
	° ′ ″	° ′ ″	° ′ ″	m. s.
St. Minvern Steeple -	50 33 30,6	0 20 28,1 E	4 51 27,6	19 25,8
St. Minvern Windmill -	50 31 55,5	0 23 23,5 E	4 48 32,2	19 14,1
St. Isey Steeple -	50 30 36,0	0 17 36,6 E	4 54 20,1	19 37,3
St. Merian Steeple -	50 31 59,3	0 13 23,8 E	4 58 31,9	19 54,1

ART. XXXVI. *Latitudes and Longitudes of such Places, in the Series of* 1799, *as have been referred to the Meridians of Dunnose and Greenwich.*

Meridian of Dunnose.

Names of Objects.	Latitude.	Longitude from Dunnose.	Longitude west of Greenwich. In degrees.	In time.
	° ′ ″	° ′ ″	° ′ ″	m. s.
Warwick Steeple -	52 16 53,0	0 23 18,3 W	1 34 54,3	6 19,6
St. Martin's Spire, Coventry	52 24 25.4	0 18 29,5 W	1 30 5,5	6 0,3
Soleyhull Spire - -	52 2 30,4	0 34 13,8 W	1 45 49,3	9 3,3
Dunchurch Windmill -	52 20 4,6	0 5 32,5 W	1 17 8,5	5 8,6

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Names of Objects.	Latitude.	Longitude from Dunnose.	Longitude west of Greenwich. In degrees.	In time.
	° ′ ″	° ′ ″	° ′ ″	m. s.
Gazebo, Bardon Hill *	52 42 47,6	0 7 12,2 W	1 18 48,2	5 15,2
Markfield Windmill	52 41 16,8	0 5 1,0 W	1 16 37,0	5 6,5
Breadon Hill Building †	52 3 16,7	0 49 59,7 W	2 1 35,7	8 6,4
Newnham Windmill	52 13 55,7	0 0 36,2 E	1 10 59,8	4 43,9
Deddington Steeple	51 59 13,9	0 7 36,1 W	1 19 12,1	5 16,8
Bloxham Spire	52 1 5,6	0 10 29,7 W	1 22 5,7	5 28,4
Aynoe Steeple	51 59 35,2	0 3 10,2 W	1 14 46,2	4 59,1
Adderbury Spire	52 0 51,6	0 6 3,7 W	1 17 39,7	5 10,6
Farthingo Steeple	51 59 45,1	0 1 42,4 W	1 13 18,4	4 53,2
Round House, Edge Hills	52 7 25,6	0 15 18,4 W	1 26 54,4	5 47,6
Round House Windmill	52 7 11,4	0 15 32,6 W	1 27 8,6	5 48,6
Wingrove Steeple	51 51 46,8	0 27 28,7 E	0 44 7,3	2 56,5
Hardwick Steeple	51 51 47,8	0 22 2,6 E	0 49 33,4	3 18,2
Luggersal Steeple, Bucks	51 50 57,3	0 9 17,2 E	1 2 18,8	4 9,2
Granborough Steeple	51 55 4,3	0 18 45,2 E	0 52 50,8	3 31,4
Bicester Steeple	51 53 46,8	0 1 48,9 E	1 9 47,1	4 39,1
Abingdon Spire	51 40 3,8	0 5 1,2 W	1 16 37,2	5 6,5
Wallingford Steeple	51 36 2,4	0 4 36,2 E	1 6 59,8	4 27,9
Great Coxwell Windmill	51 38 59,8	0 25 32,4 W	1 37 8,4	6 28,5
Drayton Steeple	51 38 35	0 6 30,1 W	1 18 6,1	5 12,4
Highworth Steeple	51 37 51,4	0 30 38,1 W	1 42 14,1	6 48,9
Witney Spire	51 46 49,9	0 17 6,9 W	1 28 42,9	5 54,8
Bampton Steeple	51 44 11,2	0 20 51,9 W	1 32 27,9	6 9,8
Radley Steeple	51 40 58,3	0 31 57,4 W	1 43 33,4	6 54,2
Buckland Steeple	51 40 53,3	0 18 21,1 W	1 29 57,1	5 59,8
Witchwood Beacon	51 50 9,8	0 20 21,6 W	1 31 57,6	6 7,8
Stow on the Wold	51 55 46,9	0 31 23,6 W	1 42 59,6	6 51,9
Sarsden Chapel	51 54 16,4	0 22 49,9 W	1 34 25,9	6 17,7
Bourton Chapel	51 59 22,5	0 33 20,7 W	1 44 56,7	6 59,8
Walford Spire	52 0 31,6	0 26 12,5 W	1 37 48,5	6 31,2
Islip Steeple	51 49 20,7	0 2 21,9 W	1 13 57,9	4 55,8
Woodstock Steeple	51 50 47,4	0 9 24,5 W	1 21 0	5 24
Kidlington Spire	51 49 44,6	0 4 51,9 W	1 16 27,9	5 5,8

Meridian of Greenwich.

Names of Objects.	Latitude.	Longitude west of Greenwich. In degrees.	In time.
	° ′ ″	° ′ ″	m. s.
Pitchcot Windmill	51 52 58,5	0 50 35,5	3 22,3
Ivinghoe Spire	51 50 9,1	0 37 51,3	2 31,4
Quainton Steeple	51 52 28,7	0 54 28,0	3 37,8
Southern Obelisk, Stow Park	52 2 2,2	1 0 27,1	4 1,8
Northern Obelisk, ditto	50 2 30,2	1 0 42,9	4 2,8

* In page 658, this is, by mistake, called Breadon Hill Summer House.

† In page 659, this building is called Gazebo.

Names of Objects.	Latitude.	Longitude west of Greenwich. In degrees	In time.
	° ′ ″	° ′ ″	m. s.
Leighton Buzzard Spire	51 54 56,5	0 39 54,4	2 39,6
Aylesbury Spire - -	51 49 18,9	0 50 18	3 21,2
Hanslope Spire - -	52 6 45,2	0 49 17,8	3 17,2
North Crawley Spire -	52 5 31,1	0 38 38,4	2 34,5
Pavenham Spire - -	52 11 36,3	0 32 27,0	2 9,8
St. Paul's Spire, Bedford	52 8 8,8	0 27 43,3	1 50,9
Sharnbrook Spire -	52 12 55,1	0 32 48,0	2 11,2
Woburn Market-House -	51 59 17,4	0 36 58,5	2 27,9
Woburn Steeple - -	51 59 21,8	0 37 0,3	2 28
Ridgemont Station - -	52 0 56,4	0 34 45,7	2 19
Wootton Steeple -	52 5 39,2	0 31 55,7	2 7,7
Cranfield Spire - .	52 4 3,1	0 36 11,1	2 24,7
Husborne Crawley Steeple	52 0 57,0	0 36 19,8	2 25,3
Souldrope Spire - -	52 14 38,6	0 33 9,1	2 12,6
Windmill near Tharfield	52 1 30,9	0 3 20,4	0 13,3
Tottenhoe Station - -	51 53 18,9	0 34 37,5	2 18,5
Chalgrave Steeple -	51 55 40,2	0 30 51,4	2 3,4
Keysoe Spire - -	52 14 58,5	0 25 24,3	1 41,6
Moulshoe Steeple -	52 2 59,0	0 40 39,6	2 42,6
Renhold Spire - -	52 9 41,5	0 24 20,1	1 37,3
Lidlington Windmill -	52 2 4,2	0 33 25,0	2 13,7
Maulden Steeple - -	52 1 52,2	0 27 20,2	1 49,3
Harlington Steeple -	51 57 48,4	0 29 18,6	1 57,2
Millbrook Steeple -	52 1 43,6	0 31 15,5	2 5
Stretley Steeple - -	51 56 42,8	0 26 12,4	1 44,8
Sauldon Windmill -	51 57 9,7	0 47 26,9	3 9,8
Knotting-Green Elm Tree	52 15 26,6	0 31 11,5	2 4,7
Ravensden Steeple -	52 10 33,9	0 25 15,7	1 41
Bow Brickhill Steeple -	52 0 1,1	0 40 13,4	2 40,9
Colmworth Spire - -	52 12 49,3	0 22 27,0	1 28,5
Sundon Windmill -	51 57 52,2	0 28 57,0	1 55,8
Silsoe Steeple -	52 0 33,0	0 25 21,4	1 41,4
Flitton Steeple -	52 0 42,1	0 27 14,4	1 48,9
Shillington Steeple - -	51 59 31,7	0 21 45,0	1 27
Westoning Steeple -	51 59 2,7	0 30 5,9	2 0,4
Wrest-Garden Obelisk -	52 0 16,2	0 25 10,7	1 40,7
Flitwick Steeple - -	51 59 58,6	0 30 27,1	2 1,8
Ampthill Steeple - -	52 1 57,8	0 29 11,7	1 56,7
St. Neot's Steeple -	52 13 34,7	0 15 49,9	1 3,3
Pollux Hill Steeple - -	51 59 31,2	0 27 8,7	1 48,6

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ART. XXXVII. *Latitudes and Longitudes of some remarkable Places, not contained in the preceding Tables.*

St. Nicholas's or Drake's Island, in Plymouth Sound.

The bearing of Kit Hill, from the meridian of Butterton, is 67° 12′ 12″, and the angle between it and the flagstaff on Drake's Island, 41° 40′ 8″; therefore, the bearing of the latter from the meridian is 71° 7′ 40″; consequently, its distance from the meridian is 60531 feet, and from the perpendicular 20692 feet, which respectively subtend 9′ 53″6, and 3′ 24″,5. These, with the latitude and longitude of Butterton, 50° 24′ 46″,3 and 3° 52′ 47″,5, give 50° 21′ 21″,1 for the latitude, and 4° 8′ 17″,9 for the longitude, of the flagstaff on Drake's Island.

The latitude and longitude of this spot was determined by Mr. BAYLEY, in the year 1792. The observations for the former were as follows:

50° 21′ 20″ ⊙'s LL.
50 21 30,5 ditto.
50 21 31 ditto.
50 21 29 α Aquilæ.
50 21 26,5 α Ophiuchi.
50 21 55 ⊙'s LL. The mean of these is 50° 21′ 28″,5.

The place chosen by Mr. BAYLEY, as I have been lately informed, was a few feet northward of the staff; therefore, 7″,4 may be taken for the true difference between our determinations.

The longitude of Mr. BAYLEY's station, found by the *moon's transit*, was 4° 18′ 52″; but the longitude deduced from the recent operations, is 4° 8′ 17″,9; there is, therefore, a difference of 10′ 34″,1 between the two determinations.

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St. Andrew's or the Old Church, at Plymouth.

The angle at Butterton, between the Old Church tower and Kit Hill, is 37° 45′ 5″,2; its bearing, therefore, south-west from the meridian, is 75° 1′ 56″; consequently, its distance from the meridian is 57505 feet, and from the perpendicular 15374 feet. These respectively subtend 9′ 24″, and 2′ 32″,1: hence, its latitude becomes 50° 22′ 13″,6, and longitude 4° 7′ 31″,6 = 16^{m} 30^{s},1 in time, west of Greenwich.

As it is of very great importance that the truths of the conclusions given in this Work should receive support, wherever I can find it, I think it right to mention the result of his Excellency the Count de BRUHL's endeavours to ascertain the longitude of Plymouth, by means of chronometers. The following is a copy of his communication, made in the year 1795.

Journey from Plymouth to London.

Green Timekeeper.

June 8th, 1783.	Mr. MUDGE's clock* at Plymouth, fast for mean time	0^{m} 32^{s},15
	Timekeeper faster than Mr. MUDGE's clock -	0 25 ,6
14th.	Timekeeper slower than London clock -	14 29 ,4
	London clock slow for mean time - -	0 36 ,5
	Difference of longitude -	16 3 ,65

Blue Timekeeper.

June 8th,	Mr. MUDGE's clock at Plymouth, fast for mean time	0^{m} 32^{s},15
	Timekeeper faster than Mr. MUDGE's clock -	0 37 ,4
14th.	Timekeeper slower than London clock -	14 17 ,2
	London clock slow for mean time - -	0 36 ,5
	Difference of longitude -	16 3 ,25
	Mean difference - -	16 3 ,55

The longitude of St. Paul's, west of Greenwich, is 23^{s},1 in

* It is, perhaps, right to observe, that Mr. T. MUDGE's transit, at Plymouth, was made by the late Mr. BIRD, and properly set up between stone pillars. The clock, the entire work of his own hands, was a most excellent one.

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time; and Mr. DUTTON's house in Fleet-street is about 2^s west of St. Paul's;* wherefore, its longitude west of Greenwich is 25^s: consequently, $16^m\ 3^s,55 + 25^s = 16^m\ 28^s,55$, is the difference of longitude between Greenwich and Plymouth, as shewn by the timekeepers.

Now the meridian of Mr. MUDGE's transit-room, at Plymouth, passed only 35 feet to the eastward of the centre of St. Andrew's Tower, his northern meridian mark being on the church itself; therefore, the longitude of the church and transit-room may be considered the same. From the survey, we find it to be $16^m\ 30^s,1$; and, from Count BRUHL's determination, making a just allowance for the difference of longitude between the late Mr. DUTTON's house and Greenwich, $16^m\ 28^s,5$.

It is left for the public, and this learned Society in particular, to determine how far the near agreement of these several methods, tends to corroborate the assertion I have advanced, of the dependence which may be placed on the deductions drawn from the observations made at Beachy Head and Dunnose. If there had been only one watch employed on the occasion, the result would not have been so satisfactory as the circumstance of two being used seems to make it. As the occasion calls for the remark, before I dismiss this article, I must observe, that the highest advantages would accrue to geography, were the ideas of the Astronomer Royal carried into execution, (and which I shall endeavour to do at some future period,) respecting the discovery of the difference of longitude between Greenwich and some very remote point on the western side of the island, (St. David's Head for instance,) by means of timekeepers,

* According to HORWOOD's Map of London, the distance from the centre of St. Paul's to Bolt Court, at the corner of which Mr. DUTTON's house is situated, is 31 chains.

carried backwards and forwards in the mail coaches. If this excellent scheme were executed, and the watches employed equal to the best now made, it is probable that the true difference of longitude would shortly be determined. The geodetical situation of St. David's Head will, ere long, be ascertained from a prosecution of the survey: a knowledge, therefore, of its true longitude would be attended with eminent advantages.

Lizard Light-Houses.

The light-houses on this head-land were observed from Pertinney and Karnbonellis. At the latter, Pertinney bears 74° 22′ 41″ south-west, from the parallel to the meridian of St. Agnes; and, as the angle between the western light-house and Pertinney is 78° 40′ 5″, it follows, that the bearing of the light-house from the said parallel is 4° 17′ 24″ south-east. Computing with this angle and the distance from Karnbonellis to the light-house, we get 3344 feet, and 126499 feet, for the distances of that object from the meridian and perpendicular of St. Agnes: therefore, admitting the length of the degree in the meridian, in the middle point between St. Agnes and the light-house, to be 60850 fathoms, and 61182 for the length of a degree of a great circle perpendicular to it, we get 20′ 47″,4, and 32″,8, for the small arcs which those spaces respectively subtend. These *data*, with the latitude and longitude of St. Agnes, 50° 18′ 27″, and 5° 11′ 55″,7, give the latitude of the light-house = 49° 57′ 44″, and longitude west of Greenwich 5° 11′ 4″,8, in time, 20^m 44^s,3.

This light-house was also observed from the station on Karnminnis. The triangle resulting from that observation, together with the angle at Karnbonellis, is

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Karnminnis - 44° 9′ 46″
Karnbonellis - - 98 1 30
Western Light-house 37 48 44; which gives 81342 feet, for the distance between the station Karnbonellis and the Light-house. This distance is said, in the Philosophical Transactions for 1797, p. 501, to be 81348 feet, which differs only 6 feet from the above determination; but it is probable the distance first given is most correct, as the two light-houses appearing nearly in the same line at Karnminnis, was the means of preventing us from clearly distinguishing the apex of either, and it was principally on this account that we preferred the observation made at Pertinney. The agreement however proves, that no inconsistency can be found to obtain with respect to the *data* before given, for settling the situation of this important headland.

In the Philosophical Transactions for 1797, page 502, it is mentioned, that the distance from the spot where the late Mr. Bradley made his observations, to the place where his meridian mark was fixed, was 800 feet. But there appears to be some inconsistency in this particular; as Mr. Bradley's own words, in an extract of a letter now before me, are, *it was just* 480 *feet.* Adding to this, 24 feet, the distance between the place of the meridian mark and the line joining the centre of the light-houses, we get the distance of the point O, or the place of the Observatory, (see Phil. Trans. 1797, p. 502,) from the line joining the light-houses W, E, = 504 feet; a space corresponding to 5″ of latitude, nearly; therefore, from the trigonometrical operations, we get,

$$\left.\begin{array}{ll} 49^\circ\, 57'\, 44'' & \text{for the latitude} \\ \text{and}\quad 5\ \ 11\ \ \ 4{,}8 & \text{for the longitude} \end{array}\right\}\text{of Mr. Bradley's station.}$$

Mr. BRADLEY's observations for finding the latitude, were made with a quadrant of one foot radius, the workmanship of Mr. BIRD; they were as follows.

Nine meridional altitudes of the sun's limb, the extreme results of which were 49° 57′ 27″,5 and 49° 57′ 44″, gave for the latitude of the Observatory - - - - -	49° 57′ 35″
Six meridional observations of the Pole Star below the Pole, the extreme results of which were 49° 57′ 35″ and 49° 57′ 20″,4, gave for the latitude - - - - -	49 57 23 ,2
Thirteen observations of Arcturus, α Coronæ Borealis, and α Serpentis, the extreme results of which were 49° 57′ 54″,7 and 49° 57′ 2″,7, gave for the latitude - - - -	49 57 29
Fifteen observations of α, β, γ Draconis, the extreme results of which were 49° 57′ 22″,2 and 49° 57′ 2″7, gave for the latitude -	49 57 33
The mean of which is -	49 57 30

According to the trigonometrical operations, the latitude is 49° 57′ 44″; there is, therefore, a difference of 14″ between the results; a quantity so large as justly to excite surprise, if it were not generally understood, that much dependance cannot be placed on observations made with an astronomical quadrant precisely similar to that made use of by Mr. BRADLEY. The *extreme* results in the above, differ so widely as to authorise the truth of the supposition on this occasion.

The longitude of the Lizard was determined by the transit of Venus, Sun's eclipse, transit of the Moon, and two emersions

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of Jupiter's first satellite, as particularly set forth in the Preface to the Nautical Ephemeris of 1791. The conclusions were as follows.

Four transits of the Moon, calculated by Mr. WALES, gave for the longitude - -		$20^m\ 30^s,6$
Two emersions of Jupiter's first satellite, calculated by ditto - - - -		21 14 ,5
Transit of Venus, calculated by	Doctor MASKELYNE	20 57 ,0
	Mr. WITCHELL -	20 56 ,5
	Mr. WALES -	20 57 ,0
Sun's eclipse, calculated by	Mr. WITCHELL -	20 44 ,5
	Mr. SEJOUR -	20 45 ,1
	Mr. EULER -	20 59 ,0
	Mr. LEXEL -	20 51 ,0
	Mean of the whole -	20 52 ,12

From the trigonometrical operations, we find the longitude in time to be $20^m\ 44^s,3$; there is, therefore, a difference of $7^s,82$ between these different determinations: this is, probably, as near as we could have expected to find it; yet it can scarcely be supposed, that of this difference, more than 2^s can be laid to the account of the survey.

In the Philosophical Transactions for 1797, p. 502, it is observed, that angles were taken at the Lizard Light-house and Naval Signal-Staff, to determine the situation of the *Point* itself. This Point, marked P in the diagram, makes an angle of $2°\ 23'\ 16''$ S W, with the parallel to the meridian of St. Agnes at the station on Karnbonellis, and is therefore 636,6 feet from that meridian, and 126394 feet from the perpendicular; therefore $49°\ 57'\ 40'',6$ is the latitude and 5 11 46 the longitude } of the Lizard Point.

Scilly Islands.

To determine the distances of the objects in these islands, from the stations near the Land's End, with sufficient accuracy, proper corrections were made for reducing the horizontal angles to those formed by the chords. On the present occasion, it will be right to use the horizontal, and not the chord angles; the distances from the meridians, and from their perpendiculars, being computed on the supposition of the earth's surface being a plane, which, within the limits of our fixed meridians, may be considered as true.

The angles for finding the distances of these objects are given in the Philosophical Transactions for 1797, p. 503; from whence, and the *data* contained in this Work, we get the bearing of

the *Day-mark* in the Island of St. Martin's from	St. Buryan	75° 44′ 52″ S W
	Pertinney	71 14 22 S W
	Sennen -	75 30 9 S W

which, combined with the distances of the stations from the meridian of St. Agnes, give

246801, 246804, 246821 feet, for the distance of the Day-mark from the meridian of St. Agnes;

and 122409, 122410, 122414 feet, for the distance of it from the perpendicular.

The mean of the first is 246809 feet, and the mean of the last 122411 feet; but the latter becomes 122419, because a line drawn from the Day-mark, perpendicular to the meridian of St. Agnes, cuts that meridian eight feet *below* the parallel. Again, we get the bearing of

the Windmill - - -	in the Island of St. Mary, from	Pertinney -	65° 32′ 30″ S W
the Flagstaff of the Fort		Pertinney -	66 53 5 S W

from whence, after a similar correction with that just made, we find the distance of

the Windmill	256304	feet from the meridian, and	143597	feet from the perpendicular of St. Agnes.
the Flagstaff	260152		140876	

From the same page, and the *data* furnished in this work, we also find the bearing of

St. Agnes Light-House from	Sennen -	68° 6′ 54″ S W
	St. Buryan	69 5 56 S W; which gives

265865, 265879 feet, for the distance from the meridian, and

149121, 149128 feet, for the distance from the perpendicular of St. Agnes.

The mean of the first is 265872 feet, and the mean of the last, when corrected, 149133 feet.

With the above data, and also the latitude and longitude of St. Agnes, we get

the latitude of	Day-mark in St. Martin's -	49° 58′ 2″,9
	Windmill, St. Mary's - -	49 54 32,7
	Flagstaff, ditto - -	49 54 59,1
	St. Agnes Light-House* - -	49 53 36,8

					In Time.
and longitude west from St. Agnes.	Day-mark	1° 2′ 43″,1	from the meridian of Greenwich. -	6° 14′ 38″,8	24m 58s,6
	Windmill	1 5 3,2		6 16 58,7	25 7,9
	Flagstaff	1 6 2,7		6 17 57,4	25 11,9
	Light House	1 7 27,7		6 19 23,4	25 21,5

* In the *Requisite Tables*, published by order of the Board of Longitude, the latitude of the Scilly Lights is said to be 49° 56′ 0″, and longitude 6° 46′ 0″. The latitude, according to the survey, is 49° 53′ 36″,8, and longitude 6° 19′ 23″,4. An error of 2′ 23″ in the latitude, may not perhaps be considered extraordinary; but how, in a maritime country, like our own, where chronometers are in such constant use, so great an error as 26′ 37″ (1^m $46^s\frac{1}{2}$ in time) in the loogitude, should have remained undetected, excepting by one person, is surprising. J. Huddart, Esq. visited the Scilly Isles, having with him a watch made by Arnold, and obtained his time at that spot in the island of St. Mary where the body of Sir Cloudsley Shovel is said to have been thrown ashore, by means of equal altitudes of the Sun's limb; he then found, comparing his time with that shewn by the watch, that 0^h 25^m 18^s was the difference between the meridians of Greenwich and this spot in St. Mary's. Now St. Agnes Light-house is about 2′ of a degree west of the place to which Mr. Huddart alludes; therefore, 25′ 18″ + 8″ = 25′ 26″ is the longitude of St. Agnes, through these means; which differs only 4″,5 in time from that found by the survey.

The Observatory of his Grace the Duke of MARLBOROUGH, *at Blenheim.*

The staff erected over the quadrant, was observed from White Horse Hill and Whiteham Hill. At the former station, the latter makes an angle of 36° 30′ 13″,5, with the parallel to the meridian of *Dunnose*. The staff, therefore, bears from the parallel 25° 59′ 29″,75 N E.; consequently, its distance from the meridian of Dunnose is 36540 feet, and from the perpendicular 446458 feet. These respectively subtend 5′ 58″,3, and 1° 13′ 21″,4; therefore, the latitude of the Observatory is 51° 50′ 28″,3, and its longitude 9′ 39″,9 from Dunnose: but 1° 11′ 36″ is the longitude of that station; therefore, 1° 21′ 15″,9, or 5′ 25″,2 in time, is the longitude of the Observatory west from Greenwich.

As the meridian of Dunnose passes at no great distance from that of Blenheim, I have deduced the latitude and longitude from the former, to avoid the errors which creep in, when computations are carried on from remote meridians. It may be worth while, however, to show that the extent of those errors would not be great, were the meridian of Dunnose neglected, and the Observatory at Blenheim referred to the meridian of Greenwich.

The distance of White Horse Hill from the meridian of Greenwich is found to be 356050 feet, and from its perpendicular 39425 feet; the bearing of Nuffield, from the parallel at that station, being 89° 59′ 27″ S E. Blenheim will, therefore, be found to bear 26° 55′ 25″ N E from the parallel at White Horse Hill; consequently, its distance from the meridian of Greenwich is 307224 feet, and from its perpendicular 135569 feet. These give the arcs 50′ 12″,4, and 22′ 16″,1; from whence we get 51° 50′ 28″,1 for the latitude, and 1° 21′ 16″ for the longitude,

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of the Observatory west of Greenwich. Either of these determinations may be taken for the true result, but I shall prefer the first.

Being favoured by his Grace with the latitude and longitude derived from astronomical observations, we have the following comparisons:

				Degrees.	Time.
Latitude	observed	51° 50′ 24″,9	Longitude west from Greenwich.	1° 21′ 6″,0	5^m 24^s,4
	computed	51 50 28 ,1		1 21 15 ,9	5 25 ,1

Observatory at Oxford.

The angle at the station on Shotover, between the Atlas on the top of the Observatory and the parallel to the meridian of Dunnose, is 79° 50′ 51″,75 N W: therefore, its distance from the meridian is 14719 feet, and from the perpendicular 416985 feet. The figure representing Atlas is $33\frac{1}{4}$ feet *due east* of the Quadrant Room; consequently, no correction will be required in the computed latitude. The space 14719 feet subtends an arc = 2′ 24″,3, and 416985 feet an arc of 1° 8′ 30″,8. These *data*, with the latitude and longitude of Dunnose, give 51° 45′ 38″ for the latitude, and 1° 15′ 29″,2 for the longitude, of the Observatory. As in the former case, with respect to Blenheim, so in the present instance, it is immaterial whether the calculations be carried on from the meridian of Greenwich or that of Dunnose, as differences of only 0″,1 in both the latitude and longitude are found in the results.

The latitude and longitude of this Observatory are given in the *Requisite Tables*; the first is 51° 45′ 38″, and the last 1° 15′ 30″, or 5^m 2^s in time. Doctor Hornsby, however, has furnished me with what he conceives to be more accurate

determinations; from which, and the above, we have the following comparisons:

				Degrees.	Time.
Latitude	observed	51° 45′ 39″,5	Longitude west	1° 15′ 22″,5	5m 1s,5
	computed	51 45 38 ,0	from Greenwich.	1 15 29 ,2	5 1 ,9

I conclude this article with expressing an opinion, that the coincidence between the computed and, no doubt, accurately observed longitude of this Observatory, affords strong reason for supposing, that the operations at Beachy Head and Dunnose, in 1794, for finding the length of a degree of a great circle perpendicular to the meridian on the earth's surface, were made with the required accuracy.

SECTION THIRD.

Trigonometrical Surveys of the Northern and Western Parts of Kent, the County of Essex, and Parts of the adjoining Counties, Suffolk and Hertford, executed in the Years 1798 *and* 1799. *(See Plate* XXXII.*)*

It will be convenient to treat of the operations carried on in the north of Kent and Essex, before we speak of those executed in the western parts of the former county.

In a former article I have observed, that from the old station at Wrotham, (General Roy's,) the view towards the north is obstructed, and also that it became necessary to select a new one: this station was found to be 205,5 feet from the other; the distance was accurately measured, and afterwards the angle taken at the *old* station, between the staff on Severndroog Tower,

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Shooters Hill, and the one newly chosen; this angle subtended 94° 19′ 0″,5.

The distance from Severndroog Tower to the old station at Wrotham, is 79960 feet. But, it must be observed, this distance is not precisely the same as that given by General Roy, because an allowance is made for the error in the reduction of the bases, in the surveys of 1787 and 1788.

With the distances 79960 feet and 205,5 feet, and the included angle, 94° 19′ 0″,5, we find the distance of the Flag-staff on Severndroog Tower, from the new station = 79944 feet; with this distance, a part of the following triangles have their sides computed.

Art. xxxviii. *Principal Triangles.*

Names of stations.	Observed angles.	Distances of the stations.	
	° ′ ″		Feet.
Wrotham - -	62 54 38	Gravesend -	45578
Gravesend - -	82 39 21		
Severndroog Tower			71762
Gravesend - -	95 53 59	Langdon Hill -	44886
Langdon Hill	53 47 25		
Severndroog Tower			88470
Gravesend - -	34 31 53	Hadleigh Steeple -	64076
Hadleigh Steeple -	43 11 51		
Langdon Hill - -			37171
Gravesend - -	30 24 19—21	Halstow Steeple -	44839
Hadleigh - -	41 46 32—33		34064
Halstow - - -	107 49 5— 6		
	179 59 57		
Gravesend -	31 38 21	Gadshill -	22277
Halstow - -	24 18 21		28390
Gadshill			
Halstow - - -	59 18 6 —5	Sheppey -	49409
Hadleigh Steeple -	49 13 33½—32		64387
Sheppey Isle - -	31 28 24 —23		
	180 0 3 ,5		

The distances of Gadshill from Halstow, and from Halstow to the Isle of Sheppey, in the following triangle, viz.

Halstow	128	34	28
Sheppey	18	18	3
Gadshill			

give the distances between Gadshill and the station in the Isle of Sheppey 70687 and 70685 feet: the mean, 70686 feet, may be taken for the true distance.

Names of stations.	Observed angles.	Distances.	
Hadleigh - -	38° 43′ 29″	Southend - - -	27596
Southend - -	119 20 5		46204
Sheppey			

To find the distance between Langdon Hill and the spindle of the weather-cock on Rayleigh Steeple, we have the following quadrilateral.

Langdon Hill	122°	2′	46″
Gravesend -	64	56	14
Halstow -	111	20	14
Rayleigh -	61	40	46
	360	0	0

which gives the distance from the centre of Rayleigh Steeple to the staff on Langdon Hill = 44131 feet; but the point on the top of Rayleigh Tower, over which the instrument was placed, was just 7 feet farther from Langdon Hill than the spindle; therefore, 44131 + 7 = 44138 feet, is the distance between Langdon Hill and the station on the steeple.—The angles in the following triangles,

Hadleigh -	134°	11′	55″
Sheppey -	16	26	30
Langdon Hill			
Langdon Hill	49	8	5
Sheppey -	27	4	46
Rayleigh			

give the distance of

the *Spindle* on Rayleigh Tower from $\left\{ \begin{array}{l} \text{Langdon Hill} = 44131 \\ \text{Hadleigh} \quad = 15554 \end{array} \right\}$ Feet.

From the preceding quadrilateral, the distance between the spindle on Rayleigh Tower and the station on Langdon Hill, was found = 44131 feet, which is the same as the other determination.

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Names of stations.	Observed angles.	Distances.	Feet.
	° ′ ″		
Halstow	95 46 57	Spindle	49413
Sheppey	42 6 39		73313
Rayleigh Tower Spindle			
Halstow	35 1 8	Prittlewell	46820
Hadleigh	99 3 3		27206
Prittlewell Steeple			
Halstow	64 16 58	Prittlewell	46823
Sheppey	55 24 34		51243
Prittlewell			
Halstow	73 45 42	Canewden	71211
Sheppey	66 39 49		74461
Canewden Steeple			
Rayleigh	53 5 0	Canewden	31438
Prittlewell	73 41 30		26189
Canewden			
Hadleigh	52 52 24	Flagstaff	51846
Halstow	86 10 13		34060
Flagstaff of the Garrison, Sheerness			
Severndroog Tower	17 48 23	Purfleet Cliff	40423
Gravesend	20 22 40		35498
Purfleet Cliff	141 48 57		
	180 0 0		
Rayleigh	97 7 27	Danbury	47514
Langdon Hill	43 18 2		68746
Danbury Spire			
Severndroog Tower	26 24 33	Frierning	105659
Langdon Hill	95 25 0		46312
Frierning Steeple	58 10 27		
Langdon Hill	88 14 19	Frierning	46314
Frierning	44 13 19		63270
Rayleigh			

Mean distance from Langdon Hill to Frierning Steeple 46313 feet.

Names of Stations.	Observed angles.	Distances.	Feet.
Frierning	92° 15′ 6″	Danbury	49020
Langdon Hill	45 26 17		68748
Danbury Steeple			
Langdon Hill	24 27 23	Signal Staff	83902
Rayleigh	132 52 23		47408
Signal Staff, Shoebury-ness			
Triptree, old station	47 8 50		
Rayleigh	73 45 24		
Frierning			
Triptree, old station, from		Rayleigh Tower	74052
		Frierning	82860
Triptree	31 59 21		
Danbury	124 20 48		
Rayleigh			
Danbury Spire from Triptree Heath			36000
Triptree, old station	100 28 19		
Tillingham Steeple	30 14 40		
Danbury Spire			
Tillingham from		Triptree	54172
		Danbury	70281
Tillingham	84 52 34	Peldon	42469
Peldon	62 39 36		78803
Danbury			
Tillingham	48 58 50	Flagstaff	57433
Peldon	83 42 46		43595
Flagstaff on St. Osyth Priory			
Peldon	20 49 10	Thorp	64802
Thorp	32 47 18		28612
Flagstaff, St. Osyth Priory			
Peldon	74 46 5	Stoke	63931*
Thorp	52 6 31		78171
Stoke Steeple			
Peldon	71 48 20	Great Tey	43475
Great Tey	75 51 12		77204
Danbury			

Names of the Stations.	Observed angles.	Distances.	Feet.
Peldon	46 14 2	Stoke	63941*
Great Tey	90 56 9		46182
Stoke			

From a former triangle, the distance between Peldon and Stoke Steeple was found to be 63931 feet; wherefore, 63936 feet, the mean, may be taken for the true distance.

Names of the Stations.	Observed angles.	Distances.	Feet.
Thorp	98 52 20	Little Bentley	20481
Little Bentley	53 2 30		
Dover Court			42981
Thorp	41 12 53	Little Bentley	20481
Little Bentley	123 30 18		
Peldon			51205
Tillingham	96 57 20	West Mersea	28924
Danbury Spire	61 46 57		79173
West Mersea			
Rayleigh	54 27 44	West Mersea	96701
West Mersea	29 13 0		
Danbury			79170
Great Tey	52 11 44		
Stoke	45 12 57		
Staircase, St. Mary's Steeple, Colchester			
	St. Mary's Steeple from Stoke		36796
Little Bromley	54 11 22	Little Bromley	44356
Stoke	47 58 26		
St. Mary's, Colchester			33706
Dover Court	18 58 19	Tattingstone	38946
Stoke	14 53 50		49250
Tattingstone			
Thorp	37 52 49	Tattingstone	50690
Stoke	39 12 4		49245
Tattingstone			
Dover Court	50 26 54	Falkenham	31651
Rushmere	38 25 20		39270
Falkenham Steeple			

The distance from Dover Court Steeple to Stoke Steeple is 84425 feet, and from Rushmere Steeple to Stoke Steeple 75955 feet; the included angle at Dover Court Steeple is 62° 38 20′. These give the distance of Dover Court Steeple from Rushmere, 50921 feet.

Names of Stations.	Observed angles.	Distances.	
	° ′ ″		Feet.
Dover Court - -	43 40 51	Tattingstone -	38946
Rushmere - - -	49 46 9		35232
Tattingstone			
Dover Court - - - -	25 55 13	Woodbridge -	59894
Rushmere - - - -	96 25 30		26346*
Woodbridge Steeple - -	57 39 17		
	180 0 0		
Falkenham - - - -	41 25 50	Woodbridge -	33761
Rushmere - - -	58 0 10		26342*
Woodbridge			
Falkenham - - -	48 42 0	Butley - -	45013
Woodbridge - - -	83 10 0		34058
Butley Steeple			
Falkenham - - -	21 58 1	Orford Light House -	60589
Butley - - - -	116 14 59		25207
Orford Light House			
Rushmere - - - -	62 45 1–0	Otley - -	29238
Woodbridge - - -	63 30 1–0		29044
Otley Steeple - - -	53 45 0		
	180 0 2		
Rushmere - - - -	40 25 30	Henley - -	21211
Otley - - - -	46 25 0		18988
Henley Steeple - -	93 9 30		
	180 0 0		
Dover Court - - -	12 43 40	Obelisk - -	26766
Rushmere - - -	13 22 10		25503
Obelisk, Woolverstone Park			
Rushmere - - -	61 35 58	Copdock - -	28984
Copdock Steeple - -	53 5 10		28057
Obelisk			
Rushmere - - - -	85 25 0	Henley - -	21209
Copdock - - - -	37 46 0		34520
Henley - - - -	56 49 0		
	180 0 0		

Names of Stations.	Observed angles.	Distances.	Feet.
Henley Copdock *Naughton Steeple*	° ′ ″ 58 32 42—40 74 30 11—10 46 57 11—10	Naughton	45518 40294
Naughton Stoke *Lavenham Steeple*	74 24 2 45 58 58 59 37 0	Lavenham	35867 48039
Lavenham Stoke *Bulmer Steeple*	67 48 30 44 59 10 67 12 20	Bulmer	36837 48248
Lavenham Bulmer *Glemsford Steeple*	47 34 25 44 18 40	Glemsford	25746 27086
Lavenham Bulmer *Topplesfield*	18 22 0 142 15 20	Topplesfield	67962 34983
Lavenham Stoke *Twinestead Steeple*	51 36 40 58 8 10	Twinestead	43349 40006*
Stoke Great Tey *Twinestead*	50 4 48 56 15 56	Twinestead	40006* 36895
Frierning Danbury *Southweald Steeple*	156 42 10 8 50 0	Southweald	30138 77622
Danbury Triptree, old Station *Gallywood Common*	151 18 36 12 0 34	Gallywood	26097 60211
Triptree, old Station Gallywood *Pleshley Steeple*	37 41 44 75 13 56	Pleshley	63213 39973
Danbury Gallywood *Pleshley*	55 31 11 91 54 46	Pleshley	48455 39964
Gallywood Pleshley *High Easter Steeple*	15 45 30 114 49 0	High Easter	47767 14293

Names of stations.	Observed angles.	Distances.	
	° ′ ″		Feet.
Danbury - - Pleshley - - - *Hatfield Broad Oak Steeple*	12 4 30 152 53 10	} Hatfield Broad Oak - {	85096 39058
Danbury - - - High Easter - - *Thaxted Spire*	25 45 6 29 43 54	} Thaxted - - {	101330 53429
Hatfield Broad Oak - Pleshley - - - *Beauchamp Roding Spire*	54 20 51 39 25 0	} Beauchamp Roding - {	24853 31806

The angle observed from the station on Danbury Steeple, between Hatfield Broad Oak and Thaxted, was 30° 33′ 40″; this, with the including sides, 85094 and 101330 feet, gives the following triangle:

Danbury - 30° 33′ 40″
Hatfield Broad Oak 92 24 0
Thaxted - 57 2 20, which gives the distance between Thaxted and Hatfield Broad Oak = 51566 feet.

Danbury - - - Peldon - - - *Stoke*	27 24 19 118 2 28	} Stoke - - - {	122630 63951

Again, the angle observed at Danbury, between Thaxted and Stoke was 66° 43′ 8″; this, with the sides which form it, Danbury and Thaxted, Danbury and Stoke, gives the following triangle:

Danbury - 66° 43′ 8″
Stoke - - 48 25 16
Thaxted - 64 51 36, from which we find 124430 feet, for the distance from Thaxted to Stoke.

The angle at Lavenham Steeple, between Stoke and Thaxted, was likewise observed, and found to be 89° 10′ 30″, which, with the distances of these latter stations from Lavenham, 48039 and 124430 feet, gives

Lavenham - 89° 10′ 30″
Stoke - - 68 7 0
Thaxted - 22 42 30, from which we find 115480 feet to be the distance from Thaxted Spire to Lavenham Steeple.

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The angle at Danbury, between Southweald and Hatfield Broad Oak, was found to be 54° 44′ 30″. The distances from Danbury to Southweald and Hatfield Broad Oak have been already found, the former being 77622 feet, and the latter 85096 feet; from these we get the triangle,

Danbury - 54° 44′ 30″
Southweald - 67 42 5
Hatfield Broad Oak 57 33 25, which gives 75104 feet, for the distance between Hatfield Broad Oak and Southweald Steeples.

In order to connect the preceding triangles with those carried on for the survey of the south-western part of Essex, and of Hertfordshire, stations were selected on Hampstead Heath, and on Highbeech in Epping Forest, to which the great theodolite was taken, as related in the article detailing the particulars of the operations in 1799. The triangles making this connection are the following. The first, namely,

Severndroog Tower 28° 58′ 10″
Southweald - 94 49 5
Langdon Hill - 56 12 45, is had from the included angle at Severndroog Tower, 28° 58′ 10″, and the sides Severndroog Tower and Southweald, Severndroog Tower and Langdon Hill: the first is 73787 feet, and the second 88470 feet. From these *data*, we obtain the distance between the station on Langdon Hill and that on Southweald Steeple = 43001 feet.

Names of Stations.	Observed angles.	Distances.	Feet.
	° ′ ″		
Severndroog Tower -	24 24 35	Brentwood -	78553*
Langdon Hill - -	62 26 39		36616
Brentwood Steeple			
Severndroog Tower -	4 33 29	Brentwood -	78553*
Southweald - -	125 53 12		7706
Brentwood			

Foot of the cross on the dome of St. Paul's from the station on Severndroog Tower 39962*. Phil. Trans. for 1787. p. 250.

Severndroog Tower -	33 53 4	Highbeech -	71534
St. Paul's - - -	51 24 12		61919
Highbeech			
Severndroog Tower -	44 34 28	Southweald -	73795*
Highbeech - - -	69 53 13		55156
Southweald			

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From the last triangle, we find the distance from Severndroog Tower to the station on Southweald Steeple to be 73795 feet; this, it will be perceived, is deduced from the distance between the cross on the dome of St. Paul's and Severndroog Tower; but 73791 feet has been found by the triangle, which is derived from the distance between the latter station and Wrotham. A difference of 4 feet on such a distance, all things considered, is not a large quantity.

Names of Stations.	Observed Angles.	Distances.	
	° ′ ″		Feet.
Severndroog Tower -	49 8 1	Brentwood -	78558*
Highbeech - - -	71 16 44		62727
Brentwood Spire			
Severndroog Tower -	51 24 12	Hampstead Heath -	64855
Highbeech - - -	58 29 19		59455
Hampstead Heath			
Highbeech - - -	24 36 5	St. Paul's - -	61919
Hampstead - -	83 1 11		25966
St. Paul's			

As it became necessary to ascertain the situation of a high building near Berkhamstead, which, for distinction sake, I shall style the Gazebo, the instrument was removed from the station on Highbeech, to another farther west of it, as some trees obstructed the view of this object from the former. To get the distance from St. Paul's to this new station, the distance between it and the old one was measured, and found = 460 feet: the angles in the following triangle were also observed.

Highbeech, old station 66° 32′ 47″
Highbeech, new station 113 3 46
St. Paul's which gives the distance from St. Paul's to the new station 61738 feet.

Highbeech, new station -	105 21 44	Gazebo - -	49631
Berkhamstead Gazebo -	41 55 23		88872
St. Paul's - -			
Southweald - -	16 46 15	Epping Windmill -	46717
Highbeech, old station -	52 16 51		17042*
Stand of Epping Windmill			
Severndroog Tower -	10 8 44	Epping Windmill -	81891
Highbeech - - -	122 10 45		17043*
Stand of Epping Windmill			

Names of Stations.	Observed angles.	Distances.	Feet.
Highbeech, old station -	99° 19′ 16″	Epping Windmill -	17049
Berkhamstead Gazebo -	17 41 25		55567
Stand of Epping Windmill			

At the new station on Highbeech, the angle between the staff on the Gazebo at Berkhamstead and the old station was observed, and found to be 141° 45′ 50″. This angle, with the measured distance between the stations, and also the distance from the Gazebo to the new station, which are respectively 460 and 49628 feet, gives 49987 feet, for the distance between the new station on Highbeech and Berkhamstead Gazebo.

Hatfield Broad Oak Steeple -	59 1 0	Hatfield Broad Oak -	87140
Berkhamstead Gazebo -	43 12 50		60219
Epping Windmill -			
Berkhamstead Gazebo -	24 9 55	Naseing - -	39173
Hatfield Broad Oak - -	17 19 38		53844
Naseing Steeple			
Hatfield Broad Oak -	107 39 57	Henham on the Mount	39265
Berkhamstead Gazebo -	20 41 30		105890
Henham on the Mount Steeple			
Hatfield Broad Oak -	71 28 54	Thorley - -	24275
Henham on the Mount -	36 6 30		39058
Thorley Steeple			
Henham on the Mount -	35 25 0	Atterbury - -	37882
Thorley Steeple - -	69 33 0		23430
Atterbury Steeple			
Henham on the Mount -	87 20 0	Rickling - -	17816
Thorley - - -	24 57 50		42169
Rickling Steeple			
Henham on the Mount -	20 54 0	Elmdon - -	45275
Rickling - -	146 35 0		29327
Elmdon Steeple			

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The angle between Albury and Elmdon Steeples was observed, at Henham on the Mount, and found to be 72° 47′ 38″. The distances from the former stations to the latter are 37882 and 45275 feet, which give the following triangle:

Henham - 72° 47′ 38″
Albury - 60 28 27
Elmdon - - 46 43 35, from whence we get the distance between Albury and Elmdon = 49701 feet.

Names of Stations.	Observed angles.	Distances.	
	° ′ ″		Feet.
Henham on the Mount - Elmdon - - - - *Thaxted Steeple*	106 30 50 23 2 40	Thaxted - -	22988 56302
Elmdon - - - - Thaxted - - - *Balsham Steeple*	71 54 10 53 18 44	Balsham - -	55262 65504
Elmdon - - - - Balsham - - - *Babraham Mount Station*	23 38 46 48 40 38	Babraham Mount -	43559 23251
Elmdon - - - - - Babraham Mount - - - *Triplow Steeple*	29 46 30 32 56 30	Triplow - -	24806 29185

The angle at Henham on the Mount, between Hatfield Broad Oak and Thaxted Steeples, is 109° 10′ 44″; and the distances of the latter stations from the former one are 39266 and 22988 feet; from these *data* we have the triangle,

Henham - - 109° 10′ 44″
Thaxted - - 45 56 29
Hatfield Broad Oak - 24 52 47, which gives 51608 feet for the distance of Thaxted from Hatfield Broad Oak.

Hatfield Broad Oak - - Beauchamp Roding - - *High Easter Steeple*	51 9 50 64 26 10	High Easter -	24858 21460
Severndroog Tower - - Langdon Hill - - *Hornchurch Steeple*	21 6 9 24 10 20	Hornchurch - -	50989 44832*
Langdon Hill - - - Gravesend - - - - *Hornchurch Steeple*	77 57 33 50 59 0	Hornchurch -	44837* 56438

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Names of Stations.	Observed angles.	Distances.	
	° ′ ″		Feet.
Gravesend	24 32 30	Purfleet Cliff	35517
Hornchurch	31 26 22		28282
Purfleet Cliff Station			
Severndroog Tower	39 44 2	Barking	25383
Hornchurch	27 16 44		35404
Staircase of Barking Steeple			
Severndroog Tower	39 41 6	Westham	28046
St. Paul's	44 15 27		25662
Westham Steeple			

ART. XXXIX. *Secondary Triangles.*

St. Paul's from Severndroog Tower 39962 feet.

Severndroog Tower	13 1 7	Limehouse	26371
St. Paul's	22 36 13		15456
Limehouse Steeple			
Severndroog Tower	9 15 30	Chigwell	57757
Highbeech	32 36 38		17242
Chigwell Steeple			
Severndroog Tower	11 57 6	Billericay	100110
Frierning	74 34 30		21506
Billericay Chapel			
Westham Steeple	45 58 0	Station	15640
Staircase of Barking Steeple	68 35 0		12077
Station on Bank of the Thames			
Station on Bank of the Thames	41 21 0	Perry's Mast House	13120
Westham Steeple	56 15 0		10424
Perry's Mast House			
Hornchurch	14 31 20	Chimney	33236
Staircase of Barking Steeple	68 52 0		9005
Chimney of Public House at Barking Creek			
Purfleet Cliff	54 57 0	Guzzard	21002
Hornchurch	46 40 0		23638
Guzzard Station			

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Names of Stations.	Observed angles.	Distances.	
	° ′ ″		Feet.
Purfleet Cliff - - - - Hornchurch - - - *Rainham Steeple*	34 11 30 32 1 0	Rainham - -	16387 17370
Purfleet Cliff - - - Hornchurch - - *Lord Eardley's, Belvidere*	81 9 0 31 50 50	Belvidere - -	16212 30369
Purfleet Cliff - - Rainham - - - *Station at Cold Harbour*	42 18 30 41 45 0	Cold Harbour -	10971 11090
Guzzard - - - Hornchurch - - - *Aveley Mill*	56 8 20 56 43 20	Aveley Mill - -	21436 21302
Purfleet Cliff - - - Hornchurch - - *Valence Tree*	34 2 40 95 3 40	Valence Tree - -	36305 20404
Gravesend - - - Severndroog Tower - - *Chadwell Steeple*	79 39 30 13 41 10	Chadwell - -	17008 70717
Gravesend - - - Chadwell Steeple - - *Greys Steeple*	35 39 0 79 31 20	Greys - - -	18479 10953
Gravesend - - - Chadwell Steeple - - - *Flagstaff on Mr. Button's House*	37 46 0 94 24 0	Flagstaff - -	22880 14054
Gravesend - - - Chadwell Steeple - - *West Thurrock Steeple*	51 43 0 80 2 30	West Thurrock -	22457 17897
Gravesend - - Hornchurch - - *Horndon Spire*	49 8 30 36 7 5	Horndon - -	33382 42833
Gravesend - - - Chadwell - - - *West Tilbury Steeple*	18 52 0 59 26 30	West Tilbury -	5617 14956
Gravesend - - - Chadwell - - - *Northfleet Steeple*	69 31 27 30 27 42	Northfleet - -	8755 16179

Names of Stations.	Observed angles.	Distances.	
	° ′ ″		Feet
Gravesend - - -	57 16 0	East Tilbury - -	16328
Chadwell - - -	59 13 30		15987
East Tilbury Flagstaff			
Chadwell - - -	51 23 0	Station - -	25526
Mr. Button's Flagstaff -	95 22 30		20031
Station near Ockendon -			
Mr. Button's Flagstaff -	54 20 30	Orset - - -	17360
Station near Ockendon -	54 54 30		17240
Orset Steeple			
Gravesend - -	45 9 13	Fobbing - -	41433
Halstow - - -	62 0 10		33270
Fobbing Steeple			
Hadleigh Station -	65 31 12	Fobbing - -	26221
Halstow - -	45 48 50		33279
Fobbing Steeple			
Halstow - -	101 39 27	Thundersley - -	41342
Gravesend - -	37 16 40		
Thundersley Steeple -			
Halstow - -	7 53 10	Hadleigh - -	5713
Hadleigh - -	117 13 23		37028
Hadleigh Spire - -			
Hadleigh - -	89 20 40	Leigh - -	15735
Halstow - - -	24 54 27		37357
Leigh Steeple Staircase -			
Halstow - -	74 23 21	Leigh - -	37359
Sheppey Station -	42 26 8		53325
Leigh Steeple Staircase			
Halstow - -	13 17 45	Sheerness -	41434
Sheppey - -	46 5 47		13063
Sheerness Fort Flagstaff			
Hadleigh - -	38 43 29	South Church -	71211
Sheppey - -	21 56 26		74461
South Church Steeple			
Hadleigh - -	11 6 2	Prittlewell -	27208
Sheppey Station -	80 16 46		5314
Prittlewell Steeple			

Names of Stations.	Observed angles.	Distances.	
	° ′ ″		Feet.
Canewden Steeple - Prittlewell - - *Little Wakering Steeple*	45 50 0 60 46 30	Little Wakering -	23850 19603
Canewden - - Prittlewell - - - *Bank Flagstaff*	64 27 0 67 46 30	Bank - - -	32739 31908
Prittlewell - - Station on Bank - *Shoebury ness*	33 10 0 39 20 30	Shoebury-ness -	21208 18302
Canewden - - Bank Flagstaff - - *Foul-ness Chapel*	32 51 30 81 20 0	Foul-ness - -	35481 19473
Rayleigh - - Peldon - - - *Foul-ness Signal Staff*	47 28 6 43 45 33	Signal Staff - -	71622 76311
Tillingham Steeple - Peldon - - - *Signal Staff, Tillingham Grange*	139 21 10 9 44 29	Signal Staff -	13990 53860
Tillingham - - Peldon - - - *Signal Staff, Bradwell Point*	43 27 58 24 10 18	Signal Staff -	18802 31591
Tillingham - - Peldon - - - *Brightlingsea Steeple*	31 2 40 100 56 20	Brightlingsea -	56094 29463
Tillingham - - West Mersey Steeple - *Tolesbury Steeple*	39 48 40 57 33 13	Tolesbury -	24611 18673
Tillingham - - Triptree, old Station - *Althorn Church*	63 55 6 35 34 3	Althorn - -	31946 49330
Tillingham - - Althorn - - - *Burnham Steeple*	26 32 10 55 49 0	Burnham - -	26664 14400
Tillingham - - Peldon - - - *Toleshunt Major Steeple*	47 33 35 56 33 25	Toleshunt -	36541 32317

Names of stations.	Observed angles.	Distances.	Feet.
	° ′ ″		
Prittlewell Steeple	33 10 0	Signal Staff	21208
Bank Flagstaff	39 20 30		18302
Signal Staff, Shoebury-ness			
Triptree, new Station	38 5 18	Maldon	19425
Danoury	30 11 27		23829
Maldon Spire			
Triptree, new Station	36 48 30	Purleigh	36118
Danbury	72 9 0		22734
Purleigb Steeple			
Danbury	17 47 32	Steple	49647
Purleigh Steeple	148 16 30		28850
Steple Steeple			
Danbury	26 17 40	Hockley	41401
Canewden	51 8 0		23555
Hockley Steeple			
Danbury	27 21 50	Hockley	41400
Rettenden	109 22 0		20170
Hockley Steeple			
Danbury	53 39 40	Rettenden	30079
Canewden	35 25 0		41810
Rettenaen Steeple			
Rettenden	34 41 0	Stow, St. Mary's	23571
Canewden	30 53 0		26131
Stow, St Mary's Steeple			
Rayleigh	71 51 18	Rettenden	20760
Langdon Station	27 38 45		42526
Rettenden Steeple			
Rayleigh	51 8 10	Runwell	21207
Langdon	28 10 20		34975
Runwell Steeple			
Danbury	48 57 22	Burghstead	53254
Rayleigh	72 39 17		42079
Great Burghstead Steeple			
Danbury	59 11 7	Hanningfield	17666
Gallywood Station	41 40 10		22822
East Hanningfield Steeple			

Names of stations.	Observed angles.	Distances.	Feet.
Frierning Steeple	36° 7′ 48″	Stock	16826
Danbury	15 38 36		30793
Stock Steeple			
Triptree, old Station	18 38 11	Southminster	55075
Tillingham Steeple	83 33 14		17711
Southminster Steeple			
Peldon Steeple	97 35 31	Layer Marney	20180
Tillingham	23 54 4		49369
Layer Marney Steeple			
Peldon	80 20 6	Signal Staff	60701
Tillingham	61 39 24		67990
Signal Staff, St. Osyth Point			
Thorp Steeple	143 7 36	Signal Staff	21517
Little Bentley	18 54 29		39844
Great Clackton Signal Staff			
Thorp	71 35 55	Great Clackton	18920
Peldon	16 58 13		61508
Great Clackton Steeple			
Dover Court Steeple	24 36 48	Finton	38998
Thorp	92 26 41		16257
Finton Steeple			
Dover Court	39 16 34	Signal Staff	34686
Thorp	70 11 16		23340
Finton Signal Staff			
Dover Court	53 15 26	Walton	26275
Thorp	47 52 22		28389
Walton Tower or Sea-mark			
Dover Court	133 57 30	Cupola	15085
Thorp	13 29 57		46517
Cupola, Landguard Fort			
Thorp	46 16 17	Ardleigh	47494
Peldon	47 1 34		46901
Ardleigh Steeple			
Peldon	106 10 16	Frating	35433
Great Tey Steeple	32 32 11		63274
Frating Steeple			

Names of Stations.	Observed angles. ° ′ ″	Distances.	Feet.
Thorp	30 17 55	Thorrington	23890
Little Bentley Steeple	90 41 23		12053
Thorrington Steeple			
Dover Court	22 10 12	Kirby	30343
Thorp	59 48 37		13247
Kirby Steeple			
Dover Court	33 8 12	Little Oakley	12216
Kirby Steeple	18 22 0		21193
Little Oakley Steeple			
Tillingham	38 45 0	Toleshunt Major	36541
Layer de la Hay Steeple	45 28 0		32082
Toleshunt Major Steeple			
Dover Court	16 48 13	Brantham	42590
Tattingstone Steeple	98 26 0		12447
Brantham Steeple			
Dover Court	30 52 58	Harkstead	19946
Rushmere Steeple	16 51 2		35319
Harkstead Steeple			
Dover Court	33 17 30	Arwarton	13053
Tattingstone	14 20 0		28941
Arwarton Steeple			
Tattingstone	66 10 0	Bradfield	20998
Arwarton Steeple	43 12 0		28059
Bradfield Steeple			
Dover Court	72 48 50	Harwich	8881
Rushmere	9 58 0		49036
Harwich Spire			
Dover Court	56 48 20	Hollesley	57475
Rushmere	67 58 30		51881
Hollesley Steeple			
Dover Court	47 7 40	Shottisham	52205
Rushmere	68 4 20		41224
Shottisham Steeple			
Dover Court	65 59 15	Bawdsey	46177
Rushmere	52 42 10		53024
Bawdsey Steeple			

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Names of Stations.	Observed angles. ° ′ ″	Distances.	Feet.
Dover Court	52 48 11	Felixstow	28926
Woodbridge Steeple	28 31 0		48262
Felixstow Signal Staff			
Dover Court	45 12 55	Bawdsey	42265
Woodbridge	44 53 0		42510
Bawdsey Signal Staff			
Rushmere	45 41 10	Orford	75267
Falkenham Steeple	103 52 0		55472
Orford Steeple			
Woodbridge	28 28 0	Rendlesham	21686
Butely Steeple	34 37 0		18204
Rendlesham Steeple			
Butely	153 23 0	Orford	15762
Rendlesham	12 20 0		33057
Orford Steeple			
Dover Court	8 2 6	Kesgrave	7371
Rushmere	66 54 0		48505
Kesgrave Steeple			
Dover Court	34 14 16	Waldringfield	45360
Rushmere	62 15 50		28841
Waldringfield Steeple			
Dover Court	30 58 10	Whertstead	40331
Kesgrave Steeple	56 8 30		24993
Whertstead Steeple			
Falkenham	30 59 0	Nacton	25098
Rushmere	36 2 50		21959
Nacton Steeple			
Dover Court	13 29 58	Capel	55220
Stoke	22 45 20		33325
Capel Steeple			
Stoke	24 14 18	Hintlesham	40790
Capel Steeple	103 0 34		17186
Hintlesham Steeple			
Stoke	29 43 10	Bildestone	42238
Lavenham Steeple	61 31 40		23821
Bildestone Steeple			

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Names of Stations.	Observed angles.	Distances.	Feet.
Stoke Bildestone Steeple *Aldham Steeple*	° ′ ″ 33 53 40 48 50 10	Aldham	32055 23746
Lavenham Naughton *Hadleigh Spire*	29 39 50 93 17 20	Hadleigh	42673 21154
Lavenham Naughton Steeple *Lindsey Steeple*	31 40 10 42 21 50	Lindsey	25138 19587
Stoke Lavenham *Newton Steeple*	23 7 30 24 48 40	Newton	27153 25413
Stoke Newton *Grotton Steeple*	27 1 0 42 49 0	Grotton	19660 13140
Bulmer Steeple Glemsford Steeple *Waldingfield Steeple*	67 27 40 53 37 50	Waldingfield	25637 29407
Lavenham Glemsford *Acton Steeple*	56 59 0 33 6 50	Acton	14065 21097
Lavenham Bulmer *Beauchamp Church, St. Paul's*	26 13 10 91 21 20	Beauchamp	41546 18360
Lavenham Topplesfield Steeple *High western part of Hedingham Castle*	12 31 50 52 7 20	Hedingham Castle	59359 16316
Lavenham Bulmer *Ridgewell Steeple*	26 57 0 123 32 0	Ridgewell	62325 33886
Stoke Steeple Naughton Steeple *Langham Steeple*	101 57 15 20 32 45	Langham	17904 49907
Stoke Steeple Great Tey Steeple *Great Horksley Steeple*	21 17 20 8 23 40	Great Horksley	13615 33859

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Names of Stations.	Observed angles	Distances.	
	° ′ ″		Feet.
Stoke	71 21 0	Great Horksley	13615
Twinestead Steeple	19 53 0		37819
Great Horksley Steeple			
Stoke	41 24 0	Mount Bures	29360
Great Horksley	109 43 0		21821
Mount Bures Steeple			
Stoke	62 30 40	Earles Colne	47756
St. Mary's, Colchester	70 48 0		44860
Earles Colne Steeple			
Great Tey	24 47 20	West Bergholt	21357
St. Mary's Colchester	33 14 0		16339
West Bergholt Steeple			
Danbury	6 6 0	Braxted	41358
Great Tey	6 56 40		36349
Braxted Steeple			
Great Tey	4 37 24	Kelvedon	36349
Braxted Steeple	11 43 36		10407
Kelvedon Steeple			
Great Tey	30 14 50	Messing	22390
Kelvedon	58 32 0		13223
Messing Steeple			
Great Tey	51 43 10	East Thorp	15462
Kelvedon	36 4 0		20616
East Thorp Steeple			
Danbury	50 48 0	Black Notley	51487
Triptree, new station	85 12 30		40039
Black Notley Steeple			
Danbury	23 51 34	Witham	35850
Triptree, old station	77 29 26		14852
Witham Steeple			
Danbury	47 47 25	Tarling	31874
Triptree, old station	58 17 35		27751
Tarling Spire			
Danbury	51 43 0	Braintree	58918
Triptree, old station	90 45 50		46252
Braintree Steeple			

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Names of Stations.	Observed angles.	Distances.	
	° ′ ″		Feet.
Triptree, new station	56 13 54	Feltstead	63574
Gallywood station	64 47 51		58409
Feltstead Steeple			
Danbury	26 31 30	Braintree	58918
Feltstead Steeple	73 49 10		27392
Braintree Steeple			
Danbury	17 39 30	Feltstead	60336
Pleshley Steeple	116 15 43		20409
Feltstead Steeple			
Triptree, new station	27 23 20	Hatfield Peverel	20267
Danbury	27 35 30		20132
S. Spire of Hatfield Peverel Abbey			
Pleshley	68 3 0	Great Leigh	24915
Feltstead	64 21 0		25635
Great Leigh Steeple			
Danbury	41 29 44	Great Baddow	16345
Pleshley	16 39 0		37796
Great Baddow Steeple			
Danbury	23 59 8	Chelmsford	24110
Pleshley	20 21 0		28186
Chelmsford Spire			
Danbury	32 38 36	Whittle	33552
Pleshley	41 51 20		27122
Whittle Steeple			
Danbury	19 16 20	Willingale Spain	60488
Hatfield Broad Oak	35 29 15		34390
Willingale Spain Steeple			
Pleshley	36 12 0	Roxwell	19937
Gallywood station	26 14 36		26630
Roxwell Steeple			
Pleshley	103 44 45	White Roding	33489
Gallywood station	34 9 50		57926
White Roding Steeple			
Southweald Steeple	27 51 51	Doddinghurst	17880
Frierning Steeple	30 14 50		16590
Doddinghurst Steeple			

Names of stations.	Observed angles.	Distances.	
	° ′ ″		Feet.
Southweald Epping Windmill *Theydon Mount Steeple*	3 49 0 7 31 0	Theydon	31098 15824
Southweald Theydon Mount Steeple *Navestock new Windmill*	49 13 0 16 26 0	Navestock	9656 25846
Southweald Theydon Mount *Theydon Garnon Steeple*	5 18 0 149 43 0	Theydon Garnon	37107 6797
Theydon Mount Theydon Garnon *Havering Steeple*	111 19 30 53 38 0	Havering	21090 24397
Severndroog Tower Highbeech Station *Cupola of a house at Woodford*	5 40 20 14 49 4	Cupola	52260 20197
Southweald Highbeech *Ruins near Ilford*	36 20 20 65 36 20	Ruins	51340 33405
Highbeech St. Paul's *Cheshunt Station*	102 38 0 26 2 0	Cheshunt	34702 77151
Berkhamstead Gazebo Naseing Steeple *Hunsdon Steeple*	25 59 0 88 51 24	Hunsdon	43157 18911
Naseing Hunsdon Steeple *Broxbourn Steeple*	94 35 0 34 41 0	Broxbourn	13899 24348
Berkhamstead Gazebo Hatfield Broad Oak Steeple *Harlow Steeple*	8 33 28 20 11 11	Harlow Steeple	62528 26964
Hatfield Broad Oak Naseing *Sabridgeworth Steeple*	19 44 10 11 48 5	Sabridgeworth	21054 34763
Thorley Steeple Albury Steeple *Great Hadham Steeple*	45 17 0 40 29 0	Great Hadham	15253 16995

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Names of stations.	Observed angles.	Distances.	
Henham on the Mount Steeple Albury Steeple - - *Bishop Stortford Steeple*	° ′ ″ 31 43 34 53 24 6	Bishop Stortford -	30524 19993
Henham on the Mount - Albury - - - *Stanstead Mountfitchet Steeple*	42 32 24 23 35 3	Stanstead Mountfitchet	16575 28009
Henham on the Mount - Stanstead Mountfitchet - *Farnham Steeple*	31 3 0 109 2 0	Farnham - -	24419 13323
Henham on the Mount - Albury - - - *Meesdon Windmill*	38 33 0 73 13 10	Meesdon - -	39054 25421
Henham on the Mount - Elmdon Steeple - - *Chimney on an octagon Lodge*	40 10 40 25 58 10	Octagon Lodge -	21677 31938
Balsham Steeple - - Elmdon - - - *Shady Camps Steeple*	75 15 8 25 0 22	Shady Camps -	23740 53410
Balsham - - - Shady Camps - - *Ashdon Steeple*	31 7 10 99 19 0	Ashdon - -	30778 16120
Danbury - - - Thaxted Spire - - *Little Saling Steeple* -	9 35 0 26 0 9	Little Saling -	76469 28886
Elmdon - - - Rickling Steeple - - *Newport Steeple*	22 27 0 64 25 0	Newport - -	26492 11216
Danbury - - - Little Saling Steeple - *Stebbing Steeple*	7 53 6 61 38 0	Stebbing - -	71826 11198

ART. XL. *Principal Triangles for the Survey of the Western Part of Kent. Plate* XXXIII.

Frant Steeple from Botley Hill 90362,4 feet.

Names of stations.	Observed angles.	Distances.	
	° ′ ″		Feet.
Frant Steeple - -	22 17 10	Sevenoaks - -	58492
Botley Hill - -	32 52 47		44032
Sevenoaks old Windmill			
Frant - - -	22 17 10	Chiddingstone -	42875
Sevenoaks Windmill -	40 52 50		24858
Chiddingstone Steeple -			
Frant - - -	35 2 17	Mount Sion - -	57874
Chiddingstone - -	97 43 43		33532
Mount Sion Station			
Frant - - -	31 28 30	East Peckham -	58964
Mount Sion - -	76 9 30		31707
East Peckham Steeple			
Mount Sion - -	48 14 0	Tudely Steeple -	31363
East Peckham - -	65 11 0		25772
Tudely Steeple			
Botley Hill - -	11 1 48	Seal Chart - -	59563
Sevenoaks Windmill -	141 42 12		18388
Seal Chart Station			
Seal Chart - -	74 10 0	Tunbridge - -	26851
Sevenoaks Windmill -	60 49 0		28101
Tunbridge Steeple			
Seal Chart - -	78 1 0	Otford Mount -	20397
Sevenoaks Windmill -	54 39 0		24462
Station on Otford Mount			
Sevenoaks Windmill - -	69 27 0	Silverden Farm -	28395
Otford Mount - -	61 24 0		30284
Silverden Farm Station			

Norwood from Severndroog Tower 39155 feet.

Norwood - -	53 7 40	Well Hill - -	57393
Severndroog Tower -	84 8 0		46155
Well Hill Station			

Names of stations.	Observed angles.	Distances.	
	° ′ ″		Feet.
Severndroog Tower Well Hill *Crayford Steeple*	55 4 14 35 0 32	Crayford	26479 37840
Well Hill Crayford *Ash Steeple*	77 37 40 48 8 40	Ash	34738 45555
Ash Crayford *Northfleet Steeple*	53 7 10 44 32 4	Northfleet	32237 36767
Ash Northfleet *Gravesend Station*	15 30 4 85 1 8	Gravesend	32664 8762
Ash Northfleet *Lord Eardley's, Belvidere*	47 33 30 97 53 40	Belvidere	56308 41951

Gravesend from Halstow 44836 feet.

Gravesend Halstow *Gadshill Station*	31 38 20 24 18 20	Gadshill	22275 28388
Halstow Sheppey *Gadshill*	128 34 28 18 18 3	Sheppey from Gadshill	70686
Sheppey Hernhill Steeple *Stockbury Steeple*	88 18 0 37 2 0	Stockbury	43144 71603
Frinstead Steeple Sheppey *Hernhill Steeple*	65 27 18 64 9 24	Hernhill	57820 58439

Art. xli. *Secondary Triangles.*

Frant Steeple Botley Hill Station *Bidborough Steeple*	26 37 20 9 52 49	Bidborough	26066 68071
Frant Chiddingstone Steeple *Station near Bidborough Church*	20 52 0 29 5 0	Station	27227 19951

Names of stations.	Observed angles.	Distances.	Feet.
Frant - - - Botley Hill - - *Remarkable Tree near Kibben's Cross*	° ′ ″ 104 24 36 13 40 51	Remarkable Tree -	24226 99201
Frant - - - Station near Bidborough Church *Cowden Steeple*	46 32 0 93 3 30	Cowden - -	41943 30485
Station near Bidborough Church Chiddingstone Steeple - *Mount Sion Station*	76 2 0 68 42 0	Mount Sion -	32194 35532
Station near Bidborough Church Mount Sion - - *Leigh Steeple*	20 37 0 10 21 0	Leigh - -	11241 22031
Frant - - - Chiddingstone - - *Ide Hill Station*	10 5 30 149 38 30	Ide Hill - -	62547 21689
Chiddingstone - - Ide Hill - - *Edenbridge Steeple* -	67 42 0 49 43 0	Edenbridge -	18639 22606
Seal Church Steeple - Otford Mount - - *Sevenoaks Steeple*	57 45 0 46 5 0	Sevenoaks -	15132 17766
Mount Sion Station - Peckham Steeple - - *Hadlow Steeple*	20 36 0 47 56 0	Hadlow - -	25291 11987
Seal Chart Station - Otford Mount - - *Sundrich Steeple*	50 45 0 86 11 0	Sundrich - -	29804 23131
Otford Mount - - Silverden Station - *Seal Steeple*	94 17 0 17 20 0	Seal - -	9705 32484
Well Hill Station - Norwood - - *Windmill, Ketson Common*	17 40 40 14 5 22	Ketson Common Windmill	26538 33103
Well Hill - - Severndroog Tower - *Flagstaff on Hayes Common*	56 39 0 37 39 0	Flagstaff - -	28273 38664

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Norwood from Severndroog Tower 32155 feet. Between the triangles

Names of Stations.	Observed angles.	Distances.	
Norwood - - - Severndroog Tower - *Hayes Common*	° ′ ″ 65 53 30 46 30 0	Flagstaff - -	Feet. 30718 38654*
Norwood - - - Hayes Common - - *Flagstaff on Addington Common*	34 27 30 39 41 0	Flagstaff - -	20391 18068
Well Hill - - - Norwood - - - *Cudham Steeple*	56 11 40 22 44 5	Cudham - -	20860 48958

Well Hill from Otford Mount 19206 feet.

Otford Mount - - Well Hill - - - *Knockholt Beeches, East End*	52 11 0 73 58 0	Knockholt Beeches -	22860 18790
Well Hill - - Crayford Steeple - - *Dome of a Race House*	22 22 46 41 17 10	Race House -	27859 16075
Well Hill - - Norwood - - - *Windmill, Bromley Common*	70 25 40 39 36 24	Windmill - -	57560 38945
Well Hill - - - Severndroog Tower - *Farnborough Station*	59 1 0 13 58 0	Farnborough -	11650 41381
Well Hill - - - Farnborough - - *St. Mary's Cray Steeple*	58 52 0 79 32 0	St. Mary's Cray -	17255 15019
Well Hill - - Norwood - *Halstead Steeple*	79 42 26 8 40 4	Halstead - -	8653 56492
Norwood - - - Severndroog Tower - *Bromley Steeple*	36 36 40 32 52 50	Bromley - -	22696 24932
Well Hill - - - Severndroog Tower - *Bromley Steeple*	32 29 0 51 13 0	Bromley - -	36198 22938

Names of Stations.	Observed angles.	Distances.	Feet.
Well Hill	14 19 0	Hayes	31069
Bromley	51 35 0		9805
Hayes Steeple			
Bromley	45 18 0	Lewisham	19640
Severndroog Tower	51 28 0		17846
Lewisham Steeple			

Severndroog Tower from Chiselhurst Steeple, 36778.

Names of Stations.	Observed angles.	Distances.	Feet.
Severndroog Tower	100 42 0	New Cross	23529
Chiselhurst Steeple	42 22 0		34309
New Cross Station			
Severndroog Tower	38 0 0	Eastcombe Point	18014
New Cross	49 55 0		14496
Eastcombe Point Station			
Severndroog Tower	49 39 0	Woolwich	9628
Eastcombe Point	31 55 0		13879
Woolwich Steeple			
Severndroog Tower	15 1 30	Bexley	23453
Crayford	57 48 20		7185
Bexley Steeple			
Well Hill	61 48 0	Charlton	22835
Crayford	36 39 0		33714
Charlton Farm			
Crayford	23 17 10	Darent	20374
Charlton Farm	28 14 0		17026
Darent Steeple			
Ash Steeple	12 56 49	Dartford Brent	33636
Crayford	30 32 18		14830
Dartford Brent Mill			
Crayford	16 16 18	Stone	21153
Stone Steeple	31 0 0		8069
Dartford Brent			
Ash	15 42 50	Hartley	7869
Northfleet Steeple	4 56 20		24750
Hartley Steeple			
Northfleet	8 40 40	Ridley	33675
Ash	101 42 0		5189
Ridley Steeple			

Names of Stations.	Observed angles.	Distances.	
	° ′ ″		Feet.
Northfleet - -	90 15 30	Southfleet - -	10290
Gravesend Station -	49 26 6		13545
Southfleet Steeple			
Gadshill - - -	28 8 54	Shottenden Mill -	119539
Sheppey Isle - -	121 36 55		66221
Shottenden Windmill			
Gravesend Station - -	40 46 7	Cliff - -	30540
Gadshill - - -	92 28 1		19967
Cliff Steeple			
Gravesend Station - -	35 48 14	Higham -	14115
Gadshill - - -	76 47 15		23489
Higham Steeple			
Gravesend Station - -	86 16 16	Gravesend -	3373
Halstow Station - -	4 18 19		44747
Gravesend Steeple			
Gravesend - - -	25 8 43	Chalk - - -	11621
Halstow - - -	8 11 44		34673
Chalk Steeple			
Gravesend - - -	59 21 48	Lower Hope Point -	28287
Gadshill - - -	72 5 57		25577
Lower Hope Point, Chimney of the Guard Room			
Gravesend - - -	99 28 57	Tilbury Fort -	6539
Gadshill - - -	15 26 18		24228
Flagstaff, Tilbury Fort			
Gadshill - - -	28 52 26	Rainham - -	38245
Sheppey - - -	26 24 22		41527
Rainham Steeple			
Gadshill - - -	128 37 56	Swanscombe - -	36747
Halstow - - -	29 12 53		58814
Swanscombe Spire			
Gadshill - -	124 43 26	Northfleet -	31034
Halstow - - -	28 58 21		52658
Northfleet Steeple			
Halstow - - -	4 37 23	Southfleet -	57736
Gravesend - -	159 53 20		13534
Southfleet Steeple			

Names of Stations.	Observed angles.	Distances.	Feet.
Gravesend	38° 36′ 50″	Shorn Mill	14947
Halstow	15 44 0		34435
Shorn Mill			
Sheppey	39 22 14	Gillingham	48453*
Stockbury	79 31 3		31257
Gillingham Steeple			
Sheppey	63 7 52	St. James's Church	20164
Gillingham	24 34 17		43257
St. James's Church, Isle of Grain			
Halstow	73 41 28	Gillingham	23822
Sheppey	28 9 15		48453*
Gillingham Steeple			
Gadshill	23 35 24	Friendsbury	11049
Sheppey	4 10 33		60721
Friendsbury Steeple			
Halstow	73 39 6	Star Inn	30617
Sheppey	35 45 47		50270
Chimney of the Star Inn			
Halstow	88 11 56	Bell Inn	47500
Sheppey	44 45 13		67466
High Staff at the Upper Bell Inn			
Sheppey	75 21 37	Hove	59215
Twinestead	50 40 20		4732
Hove Steeple			
Gadshill	17 43 23	Upchurch	44466
Sheppey	25 36 26		31395
Upchurch Spire			
Gadshill	21 19 45	Bobbing	60739
Sheppey	57 26 29		26212
Bobbing Spire			
Sheppey	46 5 47	Flagstaff	13063
Halstow	13 7 45		41434
Flagstaff, Sheerness Garrison			
Sheppey	17 13 51	Hucking	52765
Frinstead	93 18 29		15656
Hucking Spire			

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Names of Stations.	Observed Angles. ° ′ ″	Distances.	Feet.
Sheppey - - - - -	29 27 6	Hernhill - -	58439
East Church Station -	136 15 56		41564
Hernhill Steeple			
East Church - - -	44 20 17	Milton - -	32313
Sheppey - - -	95 42 22		22696
Milton Steeple			
Sheppey - - - - -	36 56 30	Iwade - -	12997
Milton - - - - -	32 24 0		14544
Iwade Steeple			
Hernhill - - -	7 28 0	Witchling - -	51579
Frinstead - - -	45 6 35		9461
Witchling Steeple			
Hernhill - -	25 1 0	Tenham - -	33833
Sheppey - - - -	25 51 16		30336
Tenham Steeple			
Tenham - - - - -	75 31 0	Bapchild - -	29846
Sheppey - - - -	24 42 40		12886
Bapchild Spire			
Sheppey - - -	21 32 42	Sheldwich - -	56869
Hernhill - - -	75 8 0		21581
Sheldwich Steeple			
Sheldwich - - - -	4 41 0	Queenborough -	60719
Sheppey - - - -	126 20 44		6156
Queenborough Steeple			
Hadleigh - - -	21 19 45	Minster - -	69035
Sheppey - - -	114 38 31		9771
Minster Steeple			
Halstow - - - -	70 9 25	St. Mary's - -	7095
Hadleigh - - -	11 54 16		32352
St. Mary's Steeple			
Hernhill - - - -	29 11 0	Feversham - -	15630
Sheppey - - - -	9 39 22		44537
Feversham Spire			
Tenham - - - -	41 29 0	Hartey - -	20617
Hernhill - - -	36 36 0		22906
Hartey Steeple			

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Names of Stations.	Observed Angles.	Distances.	
	° ′ ″		Feet.
Hernhill - - - East Church - - - *Sea Salter Steeple*	85 12 0 22 15 10	Sea Salter - -	17031 43580
Tenham - - - - - Sheppey - - - - - *Whitstable Steeple*	105 2 0 48 28 58	Whitstable - -	50935 65697

SECTION FOURTH.

Determination of the Altitudes of the Stations above the Level of the Sea; and the mean Refractions deduced from observed Angles of elevation and depression.

ART. XLII. *Elevations and Depressions.*

At Trevose Head.

The ground at Cadon Barrow - - - -	*elevated*	39′ 24″
Bodmin Down - - - - -	*elev.*	10 48
St. Agnes - - -	*depressed*	6 39
Hensbarrow - - - -	*elev.*	29 2

At Bodmin Down.

The ground at Carraton Hill - - - -	*elev.*	27 49
Trevose Head - - - -	*depr.*	22 33
Cadon Barrow - - - -	*elev.*	16 0
Brown Willy - - - -	*elev.*	54 24

Cadon Barrow.

The ground at Trevose Head - - -	*depr.*	36 49
Brown Willy - - - -	*elev*	36 3
The horizon of the sea in the direction of Trevose Head	*depr.*	30 56
Ditto in the direction north - - - -	*depr.*	31 12

St. Stephen's Down.

The ground at Black Down - - - -	*elev.*	25 21
Carraton Hill - - - -	*elev.*	35 18
Brown Willy - - - -	*elev.*	42 9

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Black Down, near Lydford.

The ground at Maker Heights	*depr.*	32′ 8″
Carraton Hill	*depr.*	3 46
St. Stephen's Down	*depr.*	35 18

Mendip Hills.

The ground at Bradley Knoll	*depr.*	6 12
Westbury Down	*depr.*	14 59
Farley Down	*depr.*	18 21
Lansdown	*depr.*	14 4
Moor Lynch	*depr.*	34 53
Dundry	*depr.*	15 45
Dundon Beacon	*depr.*	38 24
Ash Beacon	*depr.*	20 45

Dundry.

The ground at Mendip	*elev.*	5 8
Farley Down	*depr.*	10 1
Lansdown	*depr.*	3 19

Lansdown.

The ground at Dundry	*depr.*	5 44
Mendip	*depr.*	1 39

Farley Down.

The ground at Westbury	*depr.*	0 12
Mendip	*elev.*	5 51
Dundry	*depr.*	1 46

Bradley Knoll.

The ground at Bull Barrow	*depr.*	8 59
Ash Beacon	*depr.*	20 18
Westbury	*depr.*	4 36

Westbury Down.

The ground at Beacon Hill, Amesbury	*depr.*	10 9
Bradley Knoll	*elev.*	7 1
Mendip	*elev.*	1 28
Farley Down	*depr.*	9 9

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Dundon Beacon.

The ground at Moor Lynch	- *depr.*	° ′ ″	0 6 8
Lugshorn Corner	*depr.*	3 56 13	
Mendip	*elev.*	28 18	
Pilsden	*elev.*	8 38	

Moor Lynch.

The ground at Greylock's Foss-way	*depr.*	1 59 14
Lugshorn Corner	*depr.*	32 45
Dundon Beacon	*elev.*	0 9
Mendip	*elev.*	23 11
Pilsden	*elev.*	9 2
Ash Beacon	*elev.*	6 57

Greylock's Foss-way.

The ground at Moor Lynch	*elev.*	1 53 56
Dundon Beacon	*elev.*	34 48
Top of the staff (20 feet high) at Greylock's Foss-way	*elev.*	0 34

Lugshorn Corner.

The ground at Moor Lynch	*elev.*	27 21
Dundon Beacon	*elev.*	1 20 58
Top of the staff (20 feet high) at the west end of the base	*depr.*	1 9

Beacon Hill, Amesbury.

The ground at Westbury	*depr.*	4 36
Inkpin	*elev.*	6 22

Inkpin Hill.

The ground at White Horse Hill	*depr.*	10 54
Highclere	*depr.*	15 0
Beacon Hill, Amesbury		18 24

White Horse Hill.

The ground at Highclere	*depr.*	7 39
Nuffield	*depr.*	12 6
Shotover Hill	*depr.*	17 6

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Scutchamfly Barrow.

The ground at Wendover	*depr.*	5′ 36″
Whiteham Hill	*depr.*	11 20

At Shotover Hill.

The ground at Scutchamfly Barrow	*elev.*	0 20
Nuffield	*elev.*	1 27
Wendover	*elev.*	2 58
White Horse Hill	*elev.*	1 36

Brill on the Hill.

The ground at Nuffield	*depr.*	4 48
Wendover	*elev.*	3 55
Bow Brickhill	*depr.*	10 44
Epwell	*depr.*	6 57
Stow	*depr.*	7 6
White Horse Hill	*depr.*	5 45

Nuffield.

The ground at White Horse Hill	*depr.*	4 45
Top of the Staff at Brill on the Hill. Staff 13½ feet high	*depr.*	6 2
Bagshot	*depr.*	6 43
Highclere	*depr.*	4 12

N. B. The half stage belonging to the Royal Society was used at this station.

Wendover.

The ground at Brill on the Hill	*depr.*	14 59
Shotover Hill	*depr.*	17 21
Bow Brickhill	*depr.*	17 28
Stanmore	*depr.*	19 57

Stow on the Wold.

The ground at Shotover	*depr.*	13 48
White Horse Hill	*depr.*	7 30
Broadway Beacon	*elev.*	11 29
Brill on the Hill	*depr.*	14 45
Epwell	*depr.*	8 0

Broadway Beacon.

The ground at Stow	*depr.*	19 0
Epwell	*depr.*	17 25.

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Epwell.

The ground at Stow	depr.	3' 53"
Arbury Hill	depr.	6 39
Brill on the Hill	depr.	11 51
Corley	depr.	20 8
Broadway Beacon	elev.	8 31

Arbury Hill.

The ground at Epwell	depr.	14 25

Bow Brickhill.

The ground at Wendover	elev.	3 59
Kinsworth	elev.	5 35
Brill on the Hill	depr.	5 28

Kinsworth.

The ground at Brill on the Hill	depr.	12 37
Bow Brickhill	depr.	17 25
Arbury Hill	depr.	13 44
Stanmore	depr.	17 4
Lillyhoe	depr.	23 44

Bagshot Heath.

The ground at Nuffield	elev.	1 29
Stanmore	depr.	7 28

Stanmore.

The ground at Bagshot Heath	depr.	9 34

ART. XLIII. *Heights of the Stations.*

Stations.	Ground above low water mark. Feet.
Trevose Head	274
St. Agnes Beacon	621
Hensbarrow	1034
Bodmin Down	645
Black Down	1160
St. Stephen's Down	605
Bradley Knoll	973

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Stations.	Ground above low water mark.
	Feet.
Mendip	999
Westbury Down	775
Dundry	790
Lansdown	813
Farley Down	700
Moor Lynch	330
Dundon Beacon	360
Lugshorn Corner	49
Greylock's Fots-way	42
Ash Beacon	655
Cadon Barrow	1011
Brown Willy	1368
Inkpin	1011
Nuffield	757
White Horse Hill	893
Shotover Hill	599
Muzzle Hill, (Brill station)	744
Whiteham Hill	576
Wendover, ground above	905
Bow Brickhill	683
Kinsworth	904
Lillyhoe	664
Stow on the Wold	883
Epwell Hill	836
Broadway Beacon	1086
Arbury Hill	804

ART. XLIV. *Mean Terrestrial Refractions.*

Between	Mean Refractions.
Bodmin Down and Cadon Barrow	$\frac{1}{7}$
Bradley Knoll and Westbury Down	$\frac{1}{8}$
Maker Heights and Black Down	$\frac{1}{8}$
Highclere and Inkpin	$\frac{1}{8}$
St. Agnes Beacon and Trevose Head	$\frac{1}{9}$
Moor Lynch and Lugshorn Corner	$\frac{1}{11}$
Hensbarrow and Trevose Head	$\frac{1}{15}$

Wingreen and Bradley Knoll	[illegible]
Bodmin Down and Trevose Head	[illegible]
Carraton Hill and Black Down	[illegible]
Westbury Down and Mendip	[illegible]
Carraton Hill and St. Stephen's Down	[illegible]
Farley Down and Mendip	[illegible]
Beacon Hill and Westbury Down	[illegible]
Dundry and Farley Down	[illegible]
Dundon Beacon and Mendip	[illegible]
Bradley Knoll and Mendip	[illegible]
Lansdown and Mendip	[illegible]
Moor Lynch and Dundon Beacon	[illegible]
Dundry and Mendip	[illegible]
Westbury Down and Farley Down	[illegible]
St. Stephen's Down and Black Down	[illegible]
Moor Lynch and Dundon Beacon	[illegible]
Dundon and Lugshorn Corner	[illegible]
Moor Lynch and Greylock's Foss-way	[illegible]
Lugshorn Corner and Greylock's Foss-way	0
Cadon Barrow and horizon of the sea in the direction of Trevose Head	[illegible]
Ditto in a northern direction	[illegible]
Brill and Nuffield	[illegible]
Broadway and Stow	[illegible]
Epwell and Broadway	[illegible]
Highclere and White Horse Hill	[illegible]
Nuffield and White Horse Hill	[illegible]
Nuffield and Bagshot	[illegible]
Epwell and Stow	[illegible]
Brill and Stow on the Wold	[illegible]
Wendover and Bow Brickhill	[illegible]
Kinsworth and Bow Brickhill	[illegible]
Shotover and White Horse Hill	[illegible]
Epwell and Brill	[illegible]
Bow Brickhill and Brill	[illegible]

ART. XLV. *Particulars respecting the Altitudes of the Stations.*

The height of the station on Trevose Head, above the surface of the sea at low water, was determined in 1797, by levelling. The transit instrument was used for the purpose; and there is reason to believe the result, $274\frac{2}{10}$ feet, is within a very few inches of the truth.

In the Philosophical Transactions for 1797, p. 471, the height of the station on Maker Heights is said to be 402 feet; this was also found by levelling. The altitude of St. Agnes Beacon, determined from that station, is 599 feet; (see the same volume and page;) but, if the calculation be made from the base of altitude at Trevose Head, the height of that station, above the level of the sea, will be 621 feet, which gives a difference of 22 feet. It must be recollected, however, that in the first result, the computation was carried through two intermediate stations, which gave three arcs, and as many mean refractions; and, considering the extreme variableness to which refractions are liable, we are assuredly not to consider 22 feet deviation from the truth as a large quantity.

Besides St. Agnes Beacon, the altitudes of Cadon Barrow, Brown Willy, Hensbarrow, and Bodmin Down, have been determined from that of Trevose Head. Of the remaining stations, some are derived from Maker Heights, others from Dunnose: most of them are mean results, that is, each station has generally been found two ways; and, as it will serve to shew what errors proceed from irregularity of refraction, and imperfection of observation, I shall exhibit a few particulars in relation to them.

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Height of	deduced from	Feet.	Mean.
Black Down	Maker Heights	1169	1160
	Carraton Hill	1152	
St. Stephen's Down	Black Down	609	605
	Carraton Hill	600	
Westbury Down	Bradley Knoll	779	775
	Beacon Hill	771	
Farley Down	Mendip Hills	703	700
	Westbury Down	696	
Moor Lynch	Mendip Hills	335	330
	Ash Beacon	325	
Lugshorn Corner	Dundon Beacon	46	49
	Greylock's Foss-way	52	
Inkpin Beacon	Highclere	1014	1011
	Beacon Hill	1009	
Ash Beacon	Bull Barrow	653	655
	Bradley Knoll	657	

The above will sufficiently shew, what dependence is to be placed on the heights deduced from observed angles of elevation or depression; the results are, indeed, often less consistent, and frequently unsatisfactory; but, generally, they run on a parallel with these. The *data* from which all the heights have been computed, accompany this article.

The measurement of the base on Sedgemoor, shewed a fall of about 7 feet, from Lugshorn Corner to Greylock's Foss-way:

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therefore, supposing that fall to be gradual and constant, all the way from the latter station to the surface of the sea at Bridgewater Bay, we shall get 24 feet, for the height of Lugshorn Corner from the surface of the sea. The altitude of this station, deduced from that of Trevose Head, is 49 feet; and, subtracting 3 feet from it, (the height of the bank on which the instrument stood above the moor,) we get 46 feet for the height of the moor at Lugshorn Corner, above the level of the sea at Bridgewater Bay. But this height, *supposing the fall regular*, is proved to be 24 feet. There is, therefore, a difference of 22 feet, granting the whole of this to be an error on the side of the survey: but, as the general surface of the moor at Bridgewater Bay is several feet above the surface of the sea, we may take a moiety of 24 feet, for the error of the computed height of the station at Lugshorn Corner.

Art. xlvi. *Matters relating to Refraction.*

The refractions contained in this account, like those in our former Papers, tend to prove, that when rays of light pass horizontally, and considerably distant from the surface of the earth, they are less bent or refracted from their rectilinear courses, than theory and opinion have laid down as fact. It is very certain, however, that objection lies against particular conclusions drawn from such *data* as we possess; because the angles of elevation and depression of corresponding stations are observed *at different times*, and almost always, therefore, under different circumstances; but, with the experience and continual practice of thus obtaining means of computing these refractions, although we may not be able to determine the refracting power of the air under given circumstances, yet, as the causes which render

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it variable, are as likely to predominate when the angles of depression or elevation are observed from low stations as when observed from high ones, we may be enabled to make some general deductions.*

When the instrument formerly made use of by General Roy was intrusted to my care, I possessed the means of determining, in a more accurate manner than had yet been done, the refractive power of the air near the horizon. To devote much time to it, has not, as yet, been in my power; because a more rapid extension of the survey was an object of greater

* As many instances of strong atmospherical refraction have been related, and ingeniously accounted for, in some of the late publications of the Royal Society, I think it right to mention, by way of note, a very extraordinary instance of its variability.

In the month of June, 1795, when the instrument and party were stationed at Pilsden Hill, in Dorsetshire, on a particular day, at about the hour of four, I employed myself in observing the angles of depression or elevation of the surrounding hills. After I had done all that was necessary in this matter, I turned the telescope to *Glastonbury Tor*, and observed the depression of it. The air was so unusually clear, that, desirous of proving to a gentleman then with me in the observatory tent, the excellence of the telescope, I desired him to apply his eye to it: this he did, and, agreeably to a desire he expressed, I again took the depression of the upper part of the old building, which I was enabled to do with great accuracy, and found it 2" different; the first being 30',0", and the last 30',2". The unusual distinctness of this object, led me to keep my eye a long time at the telescope; and, whilst my attention was engaged, I perceived the top of the building *gradually rise* above the micrometer wire, and so continue to do, till it was elevated 10',45" above its first apparent situation; it then remained stationary, and as night drew on, the object became indistinct. The following evening, I observed the depression again, and found it 29',50". To what cause this extraordinary change in the refraction could be owing, I am at a loss to conjecture. The former part of the day had been warm, with little wind, and cloudy. The thermometer, at the time of observation, was 65°, and continued stationary for a considerable time. The sky was cloudy, but yet, as I have before observed, the air was remarkably clear. The top of Glastonbury Tor, I suppose, is about 200 feet from the surface of Sedgemoor, over a considerable tract of which, the line joining Pilsden wish that object passes. The gentleman of whom I speak, as being with me in the tent, was Captain Darcy, of the Royal Engineers, who, no doubt, well remembers the circumstance.

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importance. I did not, however, lose any opportunity which the subsequent season offered; the first was, when the instruments were at White Horse Hill and Whiteham Hill; the second, when one was stationed at Brill and the other at Arbury Hill; and the third opportunity offered itself, when one party was stationed at the latter place and the other at Wendover.

On these occasions, the instructions which I communicated to Mr. Woolcot, and by which I governed myself, were to observe the elevation or depression of the corresponding station at the expiration of every hour, beginning at six A. M. and to have the watch well regulated from observed altitudes of the sun's limb. I requested him also to be very minute in entering on his book the state of the weather; to keep the instrument properly sheltered from the wind; to be always cautious to adjust his level; and also to insert the state of the air, as to temperature and density, by noting the thermometer and barometer.

During the time we were at the two first stations, White Horse and Whiteham Hills, there was only one day when the air was sufficiently clear for the purpose; this was the 6th of June. On that day, the following observations were made *at the same time as shewn by signal.*

Whiteham Hill. June 6th, 1799.

Hours.	Wh. Horse H. Elevated.	Barometer.	Thermometer.	Remarks.
	′ ″	In. pts	Degrees	
3	6 4	29,730	60,3	Light airs at SW. Sun not shining; remarkably clear.
4	6 24	29,724	62,5	Ditto. Ditto ditto.
5	6 14	29,728	58,7	Ditto. Ditto ditto.
6	6 10	29,732	58,5	Ditto. Ditto ditto.
7	6 11	29,728	57,5	Ditto. Ditto ditto.
8	6 21	29,732	57	Very calm, and cloudy, but clear.
* 9	5 37	29,736	55,7	Ditto. Lamp at Shotover very bright. Dew falling.
*10	5 39	29,740	55,5	Ditto. Ditto.

White Horse Hill. June 6th.

Hours.	Whiteham H. Depressed.	Barometer.	Thermometer.	Remarks.
	′ ″	In. pts.	Degrees.	
3	18 21	29,412	57,7	Light airs at SW. Sun not shining; very clear.
4	18 16	29,408	59,5	Ditto. Ditto ditto.
5	18 24	29,410	57,6	Ditto. Sun shining a little; not so clear.
6	18 20	29,412	55,5	More wind. Sun not shining, and darker.
7	18 25	29,412	55,5	Calm and cloudy.
8	18 15	29,438	54,2	Quite calm, and a little dew falling.
• 9	18 10	29,438	53,4	Ditto. Fine night. Lamp at Whiteham very distinct.
•10	18 25	29,438	53,2	Ditto, but lamp rather indistinct.

Similar observations were also made when the instruments were at Brill and Arbury Hill: they were as follows.

Arbury Hill. July 11th, 1799. Watch regulated.

Hours.	Brill. Depressed.	Barometer.	Thermometer.	Remarks.
	′ ″	In. pts.	Degrees.	
9 A.M.	11 15	29,180	65 ,5	Light airs at SW. Cloudy, but sun shining now and then.
10	11 15	29,200	70 ,0	Ditto. Cloudy.
11	11 15	29,200	70 ,7	Ditto. Ditto.
12	11 6	29,199	70 ,2	Ditto. Ditto.
3 P.M.	11 6	29,162	68 ,0	Ditto. Ditto. Very clear.
4	10 5	29,168	72 ,5	Ditto. Sun shining a little, yet free from any tremor.
• 9	10 30	29,132	63 ,0	Ditto. Lamp at Brill perfectly distinct.

Brill on the Hill. July 11th, 1799. Watch regulated.

Hours.	Arbury H. Depressed.	Barometer.	Thermometer.	Remarks.
	′ ″	In. pts.	Degrees.	
9 A.M.	8 40	29,100	61 ,0	Light airs at SW. Appearances of rain from SW. Cloudy.
10	8 36	29,210	67 ,5	Ditto. Clearer, but cloudy. Arbury Hill very distinct.
11	8 36	29,210	67 ,5	Ditto. More cloudy and equally clear. [round.
12	8 36	29,210	65 ,0	The air remarkably clear and free from tremor. Cloudy all
3 P.M.	8 36	29,210	71 ,0	Ditto ditto. More cloudy.
4	8 46	29,250	71 ,5	Ditto ditto. Not so cloudy.
• 9	8 48	29,200	61,75	The lamp at Arbury H. very bright. A very fine quiet night.

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The next opportunity which offered, was at the former station and Wendover: the observations were as follows.

Arbury Hill. July 27th, 1799. Watch regulated.

Hours.	Wendover. Depressed.	Barometer.	Thermometer.	Remarks.
	′ ″	In. pts	Degrees.	
12	12 8	28,728	62 ,0	Fresh wind from SW. Rather dark weather, sun shining here and there.
1	12 3	28,734	64 ,2	Ditto. Air tremulous, ditto.
2	12 11	28,740	64 ,0	Ditto. Ditto, ditto.
3	12 10	28,738	63 ,5	Ditto. Air more steady, ditto. Clearer.
4	12 22	28,740	64 ,0	Ditto. Very steady. Sun shining a little.
5	11 50	28,740	64 ,2	Ditto. Ditto. Ditto.
6	12 17	28,740	61 ,0	Less wind, and the air very clear. Wendover perfectly distinct.

Wendover. July 27th, 1799. Watch regulated.

Hours.	Arbury H. Depressed.	Barometer.	Thermometer.	Remarks.
	′ ″	In. pts	Degrees	
5 A.M.	16 12	29,030	53 ,2	Wind at SW, rather fresh; sun shining, and air very clear.
6	16 12	29,030	53 ,0	Ditto, ditto.
7	15 26	29,030	54 ,5	Less wind, and the air very steady. Arbury Hill very distinct.
8	14 44	29,100	54 ,0	Little wind. Dew falling very fast. Ditto.

Another opportunity for making contemporary observations occurred, when the parties were on Broadway Beacon and Epwell: I place them last, because I think them inferior to the others.

Epwell. June 26th, 1799. Watch regulated.

Hours.	Broadway B. Elevated.	Barometer.	Thermometer.	Remarks.
	′ ″	In. pts.	Degrees.	
12	6 6	29,100	60,5	Wind SW. Cloudy. Much rain preceding night.
1 P.M.	6 8	29,100	63,2	Ditto, but calmer; sun not shining at Broadway.
2	6 12	29,208	60,7	Very calm, and cloudy all round.
3	6 20	29,100	59,0	Ditto. Appearances of rain in SW quarter.
4	8 32	29,100	57,5	Foggy, but easily perceive the tent at Broadway Beacon.

Broadway Beacon. June 26th, 1799. Watch regulated.

Hours.	Epwell. Depressed.	Thermometer.	Remarks.
	′ ″	Degrees.	
2	19 0	57,5	Light airs from SW. Inclinable to rain.
3	19 2	57,5	Ditto. Still more so.
4	19 3	57,5	Ditto, but misty. Barometer tube broken.

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To determine the refractions on the first arc, White Horse and Whiteham Hills, we have the distance between those stations = 88662,2 feet, which subtends an arc of 14′ 32″ nearly.

To determine those on the second, we have the distance between Brill and Arbury Hill = 146530 feet, subtending an arc of 24′ 8″,9: those on the third, Wendover and Arbury Hill, 210628 feet = 34′ 35″; and, for finding the refractions from the two last tables, we have the distance from Broadway Beacon to Epwell = 80611,4 feet, which subtends an arc of 13′ 11″ nearly.

The depressions and elevations were all taken to the ground, excepting those which are marked with asterisks. At White Horse Hill and Whiteham Hill, lamps were used at the hours of 9 and 10: they were also made use of at Arbury Hill and Brill at 9 o'clock. In the first instances, the lamps were placed (the centres of them) $1\frac{1}{2}$ feet from the bottoms of the respective instruments; and in the last $2\frac{1}{2}$ feet.

The height of the transit telescope above the ground was always $5\frac{1}{2}$ feet; therefore, an allowance must be made, at each station, for the angle which that space subtends at its corresponding one; this premised, the refraction will be found from one of the two following rules, *viz.* if A be the contained arc, and D d the observed depressions, the quantity answering to the refraction, R, will be expressed by $\frac{A - D - d}{2}$; or, if one of the angles should be an elevation, e, then $R = \frac{A + e - d}{2}$: these rules give the refractions in the following table.

Refractions found from the preceding Angles of Elevation and Depression.

1. Arc. White Horse Hill & WhitehamHill.				2. Arc. Brill and Arbury Hill.				3. Arc. Arbury Hill and Wendover.				4. Arc. Broadway Beacon and Epwell.			
Hours.	Refraction. pts. cont. arc.	Barom.	Therm.	Hours.	Refraction. pts. cont arc.	Barom.	Therm.	Hours.	Refraction. pts. cont. arc.	Barom.	Therm.	Hours.	Refraction. pts cont. arc.	Barom.	Therm.
		in. pts.	°			in. pts.	°			in. pts.	°			in. pts.	°
3 P. M.	$\frac{1}{10,8}$	29,5	58,0	9 A. M.	$\frac{1}{10,9}$	29,1	63,2	5	$\frac{1}{10,8}$	28,8	54,6	2	$\frac{1}{35,1}$	29,2	54,1
4	$\frac{1}{9,4}$	29,5	61,0	10	$\frac{1}{10,7}$	29,2	68,7	6	$\frac{1}{11,6}$	28,8	61,5	3	$\frac{1}{31,0}$	57,5	58,2
5	$\frac{1}{10,4}$	29,5	58,1	11	$\frac{1}{10,7}$	29,2	68,1					4	$\frac{1}{8,6}$	29,1	57,5
6	$\frac{1}{10,4}$	29,5	57,0	12	$\frac{1}{10,4}$	29,2	67,6								
7	$\frac{1}{10,6}$	29,5	57,0	3 P. M.	$\frac{1}{10,4}$	29,2	72,5								
8	$\frac{1}{9,3}$	29,6	55,6	4	$\frac{1}{7,4}$	29,2	72,0								
9	$\frac{1}{12,6}$	29,6	54,5	9	$\frac{1}{9,8}$	29,2	62,3								
10	$\frac{1}{14,0}$	29,5	54,3												

On examining the refractions obtained on the first arc, we perceive them to have been tolerably regular from 3 o'clock till 8; the mean being $\frac{1}{10,1}$ part of the contained arc. The height of Whiteham Hill is 576 feet, and that of White Horse Hill 893 feet, above the level of the sea: the ray passes, therefore, through a tract of air considerably elevated, as the country between the stations is, for the most part, flat and low.

The air is not often clear enough, or sufficiently free from tremulous motions, for these delicate observations. On the present occasion, however, the state of it was highly fit for the purpose; and, as care was taken, I am of opinion an error of more than 3″, taking that of the arch of altitude into the account, cannot have obtained in any of the angles. The refractions at 9 and 10 o'clock are less than at the preceding hours; but this does not appear to have been owing to any change in the refractive power of the air throughout the whole extent of the ray, because the depression of Whiteham Hill, from the other station, varied little at those hours. These changes in the observed angles of elevation at Whiteham, (44″ and 42″ being the differences,) *without* corresponding ones at White Horse Hill, prove that some *partial* alteration, from floating strata, had taken place in the refraction near the former station. Whoever considers the matter, must perceive a case may be constructed in which this will take place, causing a great variation in one of the angles, whilst the other *apparently* remains the same: and this suggested the idea, that to afford any accurate conclusions in this way, a long series of observations would be necessary. It furthermore appears, that dew could not have caused these differences at Whiteham Hill, since the same cause would equally operate to vary the observed angles at White Horse Hill; but those remained nearly the same.

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The refractions on the second and third arcs, I consider as most accurate, on account of the great distance between the stations; and also as more to be depended on, from the circumstance of the ray generally passing 300 feet above the ground.

The fourth arc affords another instance of the refraction varying at one station, and remaining constant at the other. This, no doubt, was owing to the intervention of some partial stratum of air, nearer to Epwell than Broadway Beacon. The refractions, deduced from these contemporary observations are certainly inconclusive. The mean refractions, (neglecting the fourth arc) brought under one point of view, will be as follows.

Arcs.	Mean height of ray above the sea.	Refraction. Propl. pt.	Barom.	Therm.
	Feet.		in. pts.	
1. White Horse Hill and Whiteham	734	$\frac{1}{10,9}$	29,5	57,8
2. Arbury H. and Brill, 5 first refracs.	774	$\frac{1}{10,6}$	29,2	67,8
3. Arbury Hill and Wendover -	854	$\frac{1}{11,2}$	28,8	58,1

If the air had been in a quiescent state, previous to and also at the times when these observations were made, it might be expected that the differences of altitudes in the stations would be obtained, tolerably near the truth, *barometrically*. The remarks in the tables appertaining to the first and second arcs, shew that such opportunities offered; but those which belong to the third, prove the wind to have been fresh; and, as the space between the stations which constitute the extremities of that arc is 34 miles, nearly, it is not to be expected that a true result should be obtained. The differences of altitudes of the stations constituting the extremities of the two first arcs, obtained by means of the observed angles of elevation and depression, as well

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as from the heights of the mercury in the barometer, will be as follows.

Arcs.	Obs. Ang.	Barom.	Diff.
1	317	282	35
2	60	15	45

The little done on this subject, points out the necessity of doing more; it therefore remains with me to observe, that I shall lose no opportunity of employing the apparatus committed to my charge in the best and most diligent manner, both as relating to matters of refraction, and to all others connected with the Trigonometrical Survey.

In the Introduction, page 2, it is stated that this Account would be comprized in three Sections, but it was afterwards thought more convenient to divide it into four.

In Page 45, line penult. *dele* and Prittlewell.
—— 127, —— 14, *for* 1792, *read* 1772.

Printed by W. Bulmer and Co.
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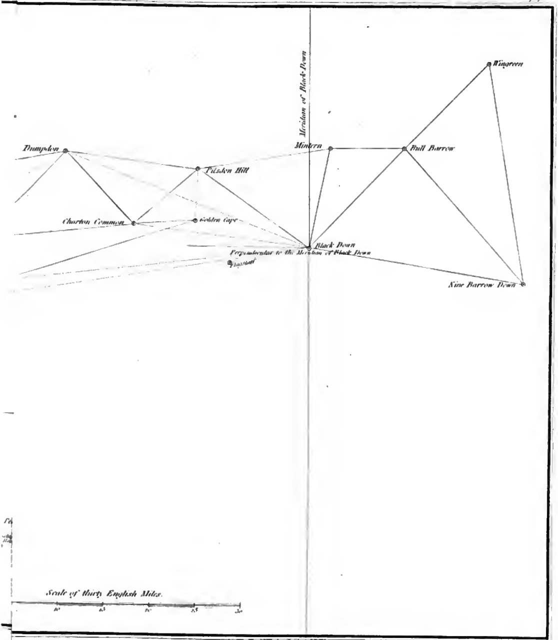
BLACK DOWN, BUTTERTON and S.T AGNES BEACON.

Philos. Trans. MDCCC. Plate XXVII. p. 728.



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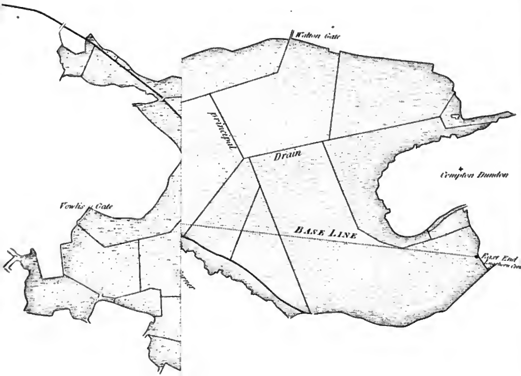

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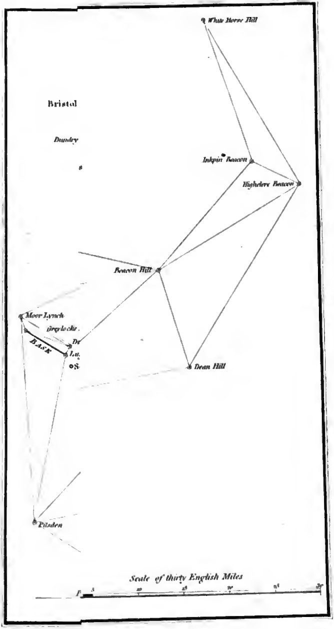
PLAN METRICAL SURVEY, 1798.



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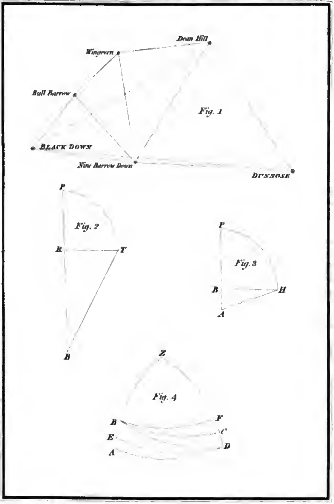
Dean Hill
Wingreen
Bull Barrow
Fig. 1
BLACK DOWN
Nine Barrow Down
DUNNOSE
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Fig. 2
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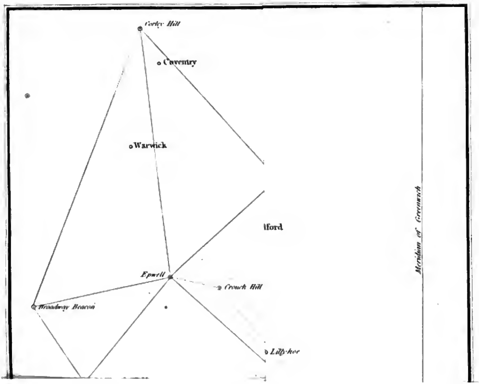
PLAN of the PRIVEY, 1799.



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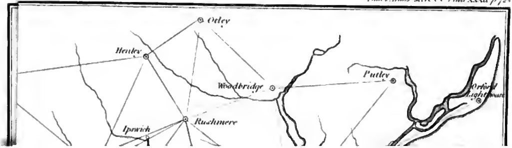
Philos. Trans. MDCCC. Plate XXXII. p. 72?



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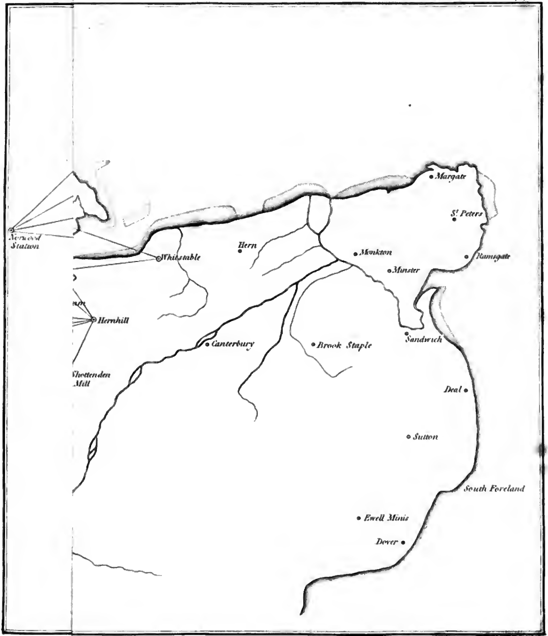
KENT, 1799.



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AN

ACCOUNT OF THE MEASUREMENT

OF AN

ARC OF THE MERIDIAN,

EXTENDING FROM

DUNNOSE IN THE ISLE OF WIGHT, TO CLIFTON IN YORKSHIRE,

IN COURSE OF THE OPERATIONS CARRIED ON FOR

THE TRIGONOMETRICAL SURVEY OF ENGLAND,

IN THE YEARS 1800, 1801, AND 1802.

BY MAJOR WILLIAM MUDGE,

OF THE ROYAL ARTILLERY, F. R. S.

INTENDED AS A SECOND PART TO VOLUME II.

ILLUSTRATED WITH EIGHT COPPER-PLATES.

FROM THE

PHILOSOPHICAL TRANSACTIONS.

LONDON:

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TRIGONOMETRICAL OPERATION IN 1787, 1788.

TRIGONOMETRICAL SURVEY, 1791—1794.

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Page

TRIGONOMETRICAL SURVEY, 1795, 1796.

PLATES.

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AN

ACCOUNT

OF THE

MEASUREMENT OF THE BASE ON HOUNSLOW HEATH,

IN THE YEAR 1784;

AND ALSO OF THE

TRIGONOMETRICAL OPERATIONS

CARRIED ON IN THE

YEARS 1787, AND 1788,

FOR THE PURPOSE OF

DETERMINING THE DISTANCE BETWEEN THE MERIDIANS OF

GREENWICH AND PARIS.

BY THE LATE

MAJOR GENERAL ROY, F.R.S. AND A.S.

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AN ACCOUNT, &c.

By William Roy.

INTRODUCTION.

ACCURATE surveys of a country are universally admitted to be works of great public utility, as affording the surest foundation for almost every kind of internal improvement in time of peace, and the best means of forming judicious plans of defence against the invasions of an enemy in time of war; in which last circumstances their importance usually becomes the most apparent. Hence it happens, that if a country has not actually been surveyed, or is but little known, a state of warfare generally produces the first improvements in its geography: for in the various movements of armies in the field, especially if the theatre of war be extensive, each individual officer has repeated opportunities of contributing, according to his situation, more or less towards its perfection; and these observations being ultimately collected, a map is sent forth into the world, considerably improved indeed, but which, being still defective, points out the necessity of something more accurate being undertaken, when times and circumstances may favour the design.

The rise and progress of the rebellion which broke out in the Highlands of Scotland in 1745, and which was finally suppressed, by his Royal Highness the late Duke of Cumberland, at the battle

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of Culloden in the following year, convinced Government of what infinite importance it would be to the State, that a country, so very inaccessible by nature, should be thoroughly explored and laid open, by establishing military posts in its inmost recesses, and carrying roads of communication to its remotest parts. With a view to the commencement of arrangements of this sort, a body of infantry was encamped at Fort Augustus in 1747, under the command of the late Lord Blakeney, at that time a Major-General; at which camp my much respected friend, the late Lieutenant-General Watson, then Deputy Quarter-Master-General in North Britain, was officially employed. This officer, being himself an engineer, active and indefatigable, a zealous promoter of every useful undertaking, and the warm and steady friend of the industrious, first conceived the idea of making a map of the Highlands. As assistant Quarter-Master, it fell to my lot to begin, and afterwards to have a considerable share in the execution of that map; which being undertaken under the auspices of the Duke of Cumberland, and meant at first to be confined to the Highlands only, was nevertheless at last extended to the Lowlands; and thus made general in what related to the mainland of Scotland, the islands (excepting some lesser ones near the coast) not having been surveyed.

Although this work, which is still in manuscript, and in an unfinished state, possesses considerable merit, and perfectly answered the purpose for which it was originally intended; yet, having been carried on with instruments of the common, or even inferior kind, and the sum annually allowed for it being inadequate to the execution of so great a design in the best manner, it is rather to be considered as a magnificent military sketch, than a very accurate map of a country. It would, however, have been completed, and many of its imperfections no doubt remedied; but the breaking out of the war of 1755 prevented both, by furnishing service of other kinds for those who had been employed upon it.

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On the conclusion of the peace of 1763, it came for the first time under the consideration of Government, to make a general Survey of the whole Island at the public cost. Towards the execution of this work, whereof the direction was to have been committed to my charge, the map of Scotland was to have been made subservient, by extending the great triangles quite to the northern extremity of the island, and filling them in from the original map. Thus that imperfect work would have been effectually completed, and the nation would have reaped the benefit, of what had been already done, at a very moderate extra-expence.

It will not be expected, that I should here attempt to assign causes for the long delay that has taken place in carrying a work of so laudable a nature into execution: suffice it to say, that a period of twelve years having elapsed, since the scheme had been first proposed, as a work that could be best executed in time of profound peace, without any thing being done in it, previous to the nation's being unfortunately involved in the American war; it was sufficiently obvious, that peace must be once more restored, before any new effort could be made for that purpose. In the mean while, as I still entertained hopes that a work which seemed to merit the attention of the public, would, at some future period, be begun, and, by gradual perseverance, ultimately brought to perfection; therefore, in the course of my ordinary military employments, wherein the very best opportunities have offered of acquiring a thorough knowledge of the country, I have not failed to observe, at least in a general way, such situations as seemed to be the best adapted for the measurement of the bases that would be necessary for the formation of the great triangles, and connecting the different series of them together.

The peace of 1783 being concluded, and official business having detained me in or near town during the whole of that summer, I embraced the opportunity for my own private amusement, to

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measure a base of 7744.3 feet, across the fields between the Jews-Harp, near Marybone, and Black-Lane, near Pancras; as a foundation for a series of triangles, carried on at the same time, for determining the relative situations of the most remarkable steeples, and other places, in and about the Capital, with regard to each other, and the Royal Observatory at Greenwich. The principal object I had here in view (besides that it might possibly serve as a hint to the public, for the revival of the now almost forgotten scheme of 1763) was, to facilitate the comparison of the observations, made by the lovers of astronomy, within the limits of the projected survey; namely, Richmond and Harrow, on the west; and Shooter's Hill and Wansted, on the east: and thinking, that a Paper, containing the result of these trigonometrical operations, might not prove unacceptable to the Royal Society, I was engaged in making the computations for that purpose, when, very unexpectedly, I found that an operation of the same nature, but much more important in its object, was really in agitation. This I saw would supersede, at least for the present, my own private observations, and perhaps render them wholly useless, unless it were as a matter of mere curiosity hereafter, to see how far such as depended on a short base, and a small instrument (a quadrant of a foot radius) would agree with those founded on a much longer base, and angles determined by a large circular instrument, being that proposed, as the best that could be made use of in the operation now to be mentioned.

In the beginning of October, 1783, Comte d'Adhemar, the French Ambassador, transmitted to Mr. Fox, then one of his Majesty's principal Secretaries of State, a Memoir of M. Cassini de Thury, in which he sets forth the great advantage that would accrue to astronomy, by carrying a series of triangles from the neighbourhood of London to Dover, there to be connected with those already executed in France, by which combined operations

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the relative situations of the two most famous observatories in Europe, Greenwich and Paris, would be more accurately ascertained than they are at present.*

This Memoir the Secretary of State, by his Majesty's command, transmitted to Sir Joseph Banks, the very respectable and worthy President of the Royal Society; who, about the middle of November, was pleased to communicate it to me, proposing at the same time, that I should, on the part of the Society, charge myself with the execution of the operation. To this proposition I readily assented, on being soon afterwards assured, through the proper official channels, that my undertaking it met with his Majesty's most gracious approbation.

A generous and beneficent Monarch, whose knowledge and love of the sciences are sufficiently evinced by the protection which HE constantly affords them, and under whose auspices they are seen daily to flourish, soon supplied the funds that were judged necessary. What his Majesty has been pleased to give so liberally, it is our duty to manage with proper and becoming frugality, consistent with the best possible execution of the business to be done, so as to make it redound to the credit of the Nation in general, and of this Society in particular.

The operation, whereof we are now to give some account, being the first of the kind, on any extensive scale, ever undertaken in this country, naturally enough subdivides itself into two parts. First, the choice and measurement of the base, with every possible care and attention, as the foundation of the work; secondly, the disposition of the triangles, whereby the base is to be connected with such parts of the coast of this island as are nearest to the coast of France, and the determination of their angles, by means of the

* M. Cassini's Memoir, with the Astronomer Royal's remarks on what is therein alleged, concerning the uncertainty of the relative situations of the two Observatories, will be given in the sequel.

best instrument that can be obtained for the purpose, from which the result or conclusion will be drawn. It is the first part only, as a subject of itself sufficiently distinct, that we are now to lay before the Society; it having been judged more advisable, to shew that no time has been lost in making reasonable progress, than to defer the account till the whole operation should be ultimately completed.

Choice of the Base. Pl. I.

1. Hounslow Heath having always appeared to be one of the most eligible situations, for any general purpose of the sort now under consideration, because of its vicinity to the Capital and Royal Observatory at Greenwich, its great extent, and the extraordinary levelness of its surface, without any local obstructions whatever to render the measurement difficult; being likewise commodiously situated for any future operations of a similar nature, which his Majesty may please to order to be extended from thence, in different directions, to the more remote parts of the island, it was proposed to Sir Joseph Banks, that the local circumstances should be actually examined; so far, at least, as to enable us to form some judgment, of the best position of the line to be measured.

The 16th day of April, 1784, being accordingly fixed on for the purpose, and Mr. Cavendish and Dr. Blagden accompanying the President on this occasion, we began our observations at a place called King's Arbour, at the north-west extremity of the Heath, between Cranford Bridge and Longford; and having proceeded from thence through the narrow gorge, formed by Hanworth Park and Hanworth Farm, we finished at Hampton Poorhouse, near the side of Bushy Park, at the south-east extremity; the total distance, from the survey of Middlesex, being upwards of five miles.

On this inspection it was immediately perceived, that the first

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part of the operation, in order to facilitate the measurement, would be, the clearing from furze bushes and ant hills, a narrow tract along the heath, as soon as the ground should be sufficiently dry to permit the base to be accurately traced out thereon.

First tracing of the Base, and clearing of the Ground. Pl. I.

2. Chiefly with a view to the more effectual execution of the work, it was judged to be a right measure to obtain and employ soldiers, instead of country labourers, in tracing the base, clearing the ground, and assisting in the subsequent operations. For, at the same time that this was obviously the most frugal method, it was evident, that soldiers would be more attentive to orders than country labourers; and by encamping on the spot would furnish the necessary centinels, particularly during the night, for guarding such parts of the apparatus, as it was foreseen must remain carefully untouched, in the frequent interims of discontinuing and resuming the work. Accordingly, a party of the 12th regiment of foot, consisting of a serjeant, corporal, and 10 men, were ordered to march from Windsor to Hounslow Heath, where they encamped on the 26th of May, close by Hanworth Summerhouse, to which spot the necessary tents, camp equipage, and entrenching tools, &c. had been previously sent.

Whatever might have been the particular direction given to the base, considered by its extremities, from consulting the plan it will easily appear, that it must always necessarily lead through the narrow gorge of the Heath formed by Hanworth Park and Hanworth Farm. The first point therefore to be attended to, in tracing it out, was, that it might lead through this pass, without interfering with certain ponds, or gravel-pits full of water, which are in it. These were easily avoided by carrying the line pretty near to Hanworth Summerhouse; and in directing the telescope from

thence towards the south-east, it was accidentally found, that by leaving Hampton Poorhouse a very little to the westward, or right, the line would coincide with a remarkable high spire, seen at the distance of eleven or twelve miles, and known afterwards to be Bansted Church. As there could not be a better situated, or more conspicuous object than this, therefore the first or south-east section of the base, comprehended between the Summerhouse and the angle of the small field adjoining to Hampton Poorhouse, was immediately directed upon it; and the soldiers were the same day set to work to clear the tract, which, at a medium, was made from two to three yards in breadth. This operation continued eight or ten days, owing to the lower part of the Heath, between Wolsey River and the Poorhouse, being encumbered with brushwood.

When the clearing of the first section was completed, the second, comprehended between the Summerhouse and the great road leading from Staines to London, was traced out in the following manner. One of the pyramidal bell-tents (whereof two had been provided, one of twenty-five, and the other of fifteen feet in height) being placed at the station near the Summerhouse, camp colours were then arranged from distance to distance, so as to be in a line with the bell-tent and Bansted Spire. In like manner, the third section, comprehended between the Staines Road and King's Arbour, was traced out.

This first tracing of the base was done by means of a common telescope held in the hand only, that no time might be lost in employing the soldiers to smooth the tract which was to be measured; because the transit instrument (my own property, for which a portable stand had been for some time preparing) was not yet ready to be applied, as it afterwards was, in tracing out the base more accurately.

The camp still remained, where it was originally pitched, at the angle of Hanworth Park, this being a very convenient position,

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with regard to the first and second sections; but being too remote from the third, that time might not be lost, and the men unnecessarily fatigued in marching backwards and forwards; therefore, one half of the party, under the command of the corporal, was detached to the northward, and quartered in the neighbouring villages, to clear the third section, while the serjeant, with the remainder, were occupied in smoothing the second. Owing to the extraordinary wetness of the season, this operation required more time than had been at first imagined, not having been entirely finished before the first week of July. We shall therefore leave it going on, and in the mean time proceed to describe the instruments that were subsequently made use of in the first and second measurements.

Steel Chain. Pl. II.

3. One of the first instruments, which that able artist Mr. Ramsden had orders to prepare, was a steel chain, one hundred feet in length, the best that he could make. Not that it was intended, nor could it be supposed, that we should absolutely abide by the result that this chain should furnish us with, for the length of the base; but it was hoped, that an instrument of this sort might be made, which would measure distances much more accurately than any thing of that kind had ever done before: and it was considered as an object of some consequence, to endeavour to simplify, and render as easy as possible, the measurement of bases in future: an operation which, hitherto, has always been found to be tedious and troublesome, to which we may now further add, uncertain likewise, when done with rods of deal, as will appear from the account hereafter to be given.

The construction of the chain, which is on the principles of that of a watch, will be understood from the representation of some of its chief parts, to the full size, in Pl. II. where the first, or zero-

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end link, is shewn both in plan and elevation, in the state in which it was originally applied to measurement on the surface of the ground. Each link consists of three principal parts; namely, a long plate; two short ones, half the thickness of the former, with circular holes near the extremities of each; and two cast-steel pins, or axes, suited to the diameters of the holes, which serve to connect the adjoining links together. The holes in the short plates are made rough, or jagged with a file; so that when they have embraced the ends of two adjoining long ones, and the pins have passed through all the holes, in rivetting their extremities, they are made perfectly fast, and as it were united to the short plates; while the embraced ends of the long ones turn freely round on the middle part of the pins.

At every tenth link the joint, just now described, has a position at right angles to the former; that is to say, the short plates lie here horizontally, and the pins passing through them stand vertically. Thus, there being in the whole chain two hundred cast-steel pins, one hundred and eighty lie horizontally; and twenty, including the two by which the handles are attached, stand vertically. These cross joints, which were chiefly intended that the chain might fold up in a smaller compass, by returning upon itself at every tenth link, are likewise useful in presenting a horizontal surface, to which small circular pieces of brass are screwed, with figures 1, 2, 3, &c. to 9, engraved on them, denoting the decimal parts of the length. Thus the middle cross joint, or that which separates the 50th from the 51st link, is shewn in the Plate with the figure 5 upon it.

The chain, in its first construction (for we are now to point out some alterations that were afterwards made in it), was one hundred feet in length, including the two brass handles; in the extremity of each of which there was a semicircular hole, of the same diameter with the steel arrows successively fixed in the

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ground, and serving to keep the account of the number of chains, when applied to common measurement. In this its first mode of application, it was soon discovered, as we shall have occasion to mention hereafter, how admirably the chain performed; and that, with some farther precautions, a still greater degree of exactness might be attained, by supporting it on stands, or even on planks, laid on, or but little removed from, the common surface of the earth. For this purpose, the two end links were altered, each being now made equal to one foot, exclusive of the handles. By referring to Pl. II. the nature of this alteration will be easily conceived. It consisted in screwing to the under side of the handles, very near the joints, two feather-edged pieces of brass; * the one denoting zero, and the other 100 feet. Over the dart at the first, a plummet with a fine silver wire being suspended, that wire, by a very simple apparatus, hereafter to be described, may be brought accurately to coincide with any point whatever of commencement: and at the second, a fine line with a knife, or other sharp instrument, being drawn on a piece of card placed there for the purpose, and changed as often as needful; or, as was likewise practised, and found to answer better, a line on a moveable slide of brass, attached to the top of the stand or plank, being brought to coincide with the feather-edge, and then fastened underneath; the extremity of the 100 feet is readily ascertained: and thus the measurement may be continued on with great accuracy to any distance at pleasure.

That the chain, in this its altered state, may still be advantageously applied to ordinary measurement on the surface of the earth, the pieces above described, having steady pins, and being fastened with screws, can be easily removed, and others, exactly of the same length, substituted in their stead, with semicircular holes (as re-

* They were originally of brass, but are now of steel, that the edges by being harder might run less risk of being damaged.

presented in the Plate by dotted lines near the joint of the handle) to receive the steel arrows, then to be made use of in the manner already mentioned.

This most excellent chain seems not to have suffered any perceptible extension from the use that has hitherto been made of it. It is so accurately constructed, that when stretched out on the ground, as in common use, all the long plates lying vertically or edge-wise, if a person, laying hold of either end with both hands, gives it a flip or jerk, the motion is, in a few seconds, communicated to the other end, in a beautiful vertical serpentine line; when the person, holding that handle, receives a sudden shock, by the weight of the chain pulling him forcibly. The chain weighs about eighteen pounds, and when folded up is easily contained in a deal box, about fourteen inches long, eight inches broad, and the same in depth.

Deal Rods. Pl. III.

4. The bases which have hitherto been measured in different countries, with the greatest appearance of care and exactness, have all, or for the most part, been done with deal rods of one kind or other, whose lengths being originally ascertained by means of some metal standard, were, in the subsequent applications of them, corrected by the same standard. Having thus had so many precedents, serving as examples to guide us in our choice, it was natural enough that we should pursue the same method in the measurement to be executed on Hounslow Heath; taking, however, all imaginable care, that our rods should be made of the very best materials that could be procured; with this farther precaution, that by trussing them, they should be rendered perfectly inflexible, a circumstance not before attended to.

As some difficulty had been found in procuring well seasoned pine wood of sufficient length, and perfectly free from knots, for

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the intended purpose; therefore Sir Joseph Banks had early applied to the Admiralty for assistance in this respect; and forthwith obtained an order to be furnished with what we might have occasion for, from his Majesty's yard at Deptford, where an old New England mast, and also one of Riga wood, were speedily cut up for our use.

New England white pine is lighter, less liable to warp, and less affected by moisture, than Riga red wood. But the New England mast, when it came to be very minutely examined, was found to be too much wounded by shot-holes in some parts, or too much decayed or knotty in others, to afford us a sufficiency. This being the case, we had recourse to the Riga wood, which was indeed extremely smooth and beautiful; and so perfectly straight grained, that a fibre of it, when lifted up, might be drawn, like a thread, almost from one end to the other.

It had been in contemplation to make the rods of twenty-five or thirty feet in length; and one of the former dimensions was actually constructed: but this being found to be rather too unwieldy, it was judged best to content ourselves with those of about twenty feet.

Different opinions have been entertained with regard to the best mode of applying rods in measurement; some contending that contacts, or that of butting the end of one rod against the end of the other, is the best; while others (with more probability of being right) are of opinion, that the adjustment by the coincidences of lines should have the preference. The first is undoubtedly the most expeditious method; but seems at the same time to be liable to this very objectionable circumstance, that the probable errors fall all one way: whereas, in the second method, although by far the most tedious, the errors of coincidence falling sometimes on one side, and sometimes on the other, they compensate for, or destroy each other; and therefore no error is committed.

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With the view of satisfying both parties, and in order to put the matter, if possible, out of doubt, it was judged proper to construct the rods in such a manner as to admit of both methods being tried, that we might adhere to that which should be found by experience to be the best.

Three measuring rods were accordingly ordered to made, and also a standard rod, with which the former were from time to time to be compared. Their general construction will be better conceived from the plan and elevation, and other representations of their principal parts, in Pl. III. than by any description, however particular, conveyed in words. It will be sufficient to say, that the stems of the three measuring rods are each twenty feet three inches in length, reckoning from the extremities of the bell-metal tippings; very near two inches deep; and about $1\frac{1}{4}$ inch broad. Being trussed laterally and vertically, they are thereby rendered perfectly, or at least as to sense, inflexible. The standard rod could only be trussed laterally; and it is justly represented by the plan of the other rods, excepting that its stem is something stronger, and that it has two or three inches at each end of extra-length, the reasons for which differences will appear hereafter.

By referring to the Plate it will be observed, that two narrow pieces of ivory, each fastened with two small screws, are inlaid into the upper surface of the rods, within one inch and a half of the extremities of the tippings. These ivory pieces received the fine black lines cut into them when the lengths of the rods were laid off, in the manner hereafter to be mentioned, and accurately determined the intermediate distance of 20 feet, or 240 inches, the measure to be used in the application by coincidences: whereas, in that by contacts, the space comprehended between the extremities of the projecting lips of the tippings, is 243 inches.

Immediately behind each ivory piece, a cavity is formed underneath, in the middle of the stem. This receives a brass wheel,

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about eight-tenths of an inch in diameter, whose axis turns in the fork of a brass spring, five inches long, fastened by a screw to the under surface just before the cross feet. These springs are only of such strength as to permit the wheels to be forced up into the cavities by the weight of the rod, which, in its adjusted state, always rests entirely on the surfaces of the two stands that support its extremities. But when the rod is to be raised from the stands, then the milled-headed screws, projecting above the upper surface, and standing over the middle of the springs, being brought to act, the wheels are thereby pressed downwards, and receive the full weight of the rod, which is then easily moved backwards or forwards to its true position, either of contact or coincidence.

The cross feet, placed about $5\frac{1}{2}$ inches from the ends of the rods, and $1\frac{3}{4}$ inch from the insertion of the trussings, are each about nine inches long, $1\frac{1}{2}$ broad, and nearly an inch in depth, having their lower surfaces level with that of the stem. By means of these, the rods are not only kept more steady on the stands, against the common action of the wind upon the trussings; but they likewise serve as holds for the vertical and horizontal brass clamps, whereby the rods are made fast to the stands on one side or other, and in both modes of application, contacts and coincidences; as will be more fully explained hereafter, in describing the tops of the stands.

Brass Standard Scale, and Method of laying off the Lengths of the Deal Rods.

5. At the sale of the instruments of the late ingenious optician Mr. James Short, I purchased a finely divided brass scale, of the length of 42 inches, with a Vernier's division of 100 at one end, and one of 50 at the other, whereby the 1000th part of an inch is

very perceptible. It was originally the property of the late Mr. Graham, the celebrated watchmaker; has the name of Jonathan Sisson engraved upon it; but is known to have been divided by the late Mr. Bird, who then worked with Sisson.

It is sufficiently well known to this Society, that their brass standard scale, about 42 inches long, which contains on it the length of the standard yard from the Tower, that from the Exchequer, and also the French half-toise, together with the duplicate of the said scale, sent to Paris for the use of the Royal Academy of Sciences, were both made by Mr. Jonathan Sisson, under Mr. Graham's immediate direction. Now, although there seemed to be every reason to suppose, that the scale at present in my possession, originally Mr. Graham's property, would correspond with those above mentioned, which he had been directed by the Royal Society, with so much care and pains, to provide; yet, that nothing of this sort might remain doubtful, it was judged right, in settling the absolute length of the base, which I measured near London in 1783, as has been mentioned in the introduction to this paper, that the two scales should be actually compared. Having accordingly obtained an order from the President, for admission into the Society's apartments, I went there in the afternoon of the 13th of August, and laid both scales, taken out of their cases, on the table of the meeting-room, with thermometers alongside of them, that they might acquire the same temperature. On the forenoon of the 15th of August the comparison was made, with the assistance of Mr. Ramsden, who for that purpose carried along with him his curious beam-compass, whose micrometer-screw shews very perceptibly a motion of $\frac{1}{5000}$th part of an inch. Thus the extent of three feet, being carefully taken from the Society's standard, and applied to my scale, it was found to reach exactly to 36 inches, the temperature being 65°. In like manner, the beam-compass being applied to the length of the Exchequer

yard, the extent was now found by the micrometer to over-reach that yard by $\frac{69}{10000}$th, or nearly $\frac{7}{1000}$th parts of an inch.

Having thus shewn that my scale is accurately of the same length with the Society's standard, it remains to point out the use that was made of it, for ascertaining the lengths of the deal rods, intended for the operation on Hounslow Heath. In the first place, Mr. Ramsden prepared a beam-compass, sufficient to take in twenty feet, trussed in all respects like the measuring rods, but something deeper, and fitted as usual with proper points and micrometer. The standard rod being now constructed was laid on the shop-board, strongly framed for the purpose, and nearly level. To one side of it, at the distance of about twenty feet two inches from centre to centre, two strong bell-metal cocks were firmly screwed. These cocks were about $2\frac{1}{4}$ inches in length, three-eighths in thickness, and rose above the stem nearly two inches, so as to be on the same plane with the surface of the measuring rods, when placed upon it.

A large plank, cut from the New England mast, upwards of thirty feet long, nine or ten inches broad, and about three inches thick, being set edgewise in the same room, on part of the stands now ready for the operation, was, in that position, planed perfectly smooth and straight. A silver wire being then stretched very tight, along the middle of the plank, from one end to the other, six spaces of forty inches each were marked off by the side of the wire, at which points seven brass pins, about one-tenth of an inch in diameter, were driven into the wood, and their tops polished with the stone. During the whole of this operation, and that which followed, the thermometer, lying by the side of the brass scale, continued steadily at or very near 63°.

A fine dot being now made on one of the extreme pins, and the silver wire being stretched over the dot, and as near as possible over the middle of the other pins, in which position it was made

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fast; the extent of forty inches, taken with the utmost care from the brass scale, was then marked off, by placing one point of the beam-compass in the dot, and with the other describing a short faint arc on the surface of the second pin. The beam being then removed, and one point placed in the intersection of the arc and wire, with the other point a dot was made on the third pin, under the middle of the wire. Upon this dot, as a centre, a faint arc was next described on the same pin where the first had been traced. In this manner the six times forty inches were marked off, alternately with dots and arcs; a method found by Mr. Ramsden, in his practice, to be more accurate, than when dots only are made use of.

The exact length of twenty feet, thus obtained, was next taken between the points of the long beam-compass, and transferred to the tops of the bell-metal cocks, placed, as has been already mentioned, on the side of the standard rod, in such manner as to leave more than one inch and a half of the said cocks beyond or without the lines denoting the extent of the twenty feet. This being done, the measuring rods were successively placed on the standard, and their sides applying close to the cocks, the distance of twenty feet was readily transferred from them to the inlaid ivory pieces, on which fine lines were afterwards cut, by marks accurately made for that purpose.

With regard to the adjustment of the lips of the bell-metal tippings, which extend exactly one inch and a half beyond the ivory lines, so as to make the total length of the rod 243 inches, it is to be observed, that they terminate in flat curves of $3\frac{1}{2}$ inches radius, passing through the inch and half points, to which they were cautiously ground down, that at first they might rather exceed than be defective in length. Any two of the rods, lying in the same plane, and also in the same straight line, being brought into contact with each other; if of the true length, the space in that

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position, comprehended between the two lines on the inlaid ivory pieces, must be exactly three inches. For the purpose of this adjustment, the extent of three inches was therefore taken from the brass scale and cut upon the side of a detached piece of ivory; which being readily applied to the aforesaid intermediate space, the same was gradually reduced, by grinding the lips equally, till it exactly corresponded with that taken from the scale.

The three rods are numbered by a cipher on the surface of the metal at each end, 1.2; 3.4; 5.6; and that being the order in which they were to be applied in actual measurement, so it was likewise the order in which they were adjusted; that is to say, the rod 1.2 was adjusted with 3.4, and with 5.6; and the rod 3.4 was, in like manner, adjusted with 1.2 and 5.6.

One of these deal rods, when finished, was found to weigh twenty-four pounds. They were intended to be contained in two chests, one large and the other smaller. The large chest, which is about $2\frac{1}{2}$ feet deep, may be called a double one, because it has two lids that lift quite off, which, in turning upside down, become alternately top and bottom, having between them, but much nearer to the one than the other, a bottom that is common to both. The shallow side holds the standard rod; and the other, two of the measuring rods; which last is rendered practicable by having one of the side braces of each fixed only with screws, so as to be removed and replaced at pleasure. Thus one of the rods being laid in its place, the other is put over it in an inverted position; and both having the proper fastenings to keep them in their positions, the lid is then put on, and fixed by screws. The chest being now turned upside down, and the other lid removed, the standard is thereby discovered resting on the common bottom, which has bands laid across it for the purpose, a few inches below what has now become the surface of the chest. It was necessary that the standard should rest thus high, both that the light might come

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freely upon it, and that, being supported by the deep sides of the chest, it might be prevented from twisting, for it will be remembered that it is only trussed laterally. By means of a small brass spring fixed to each end of the standard, a fine silk thread, as being less liable to accident than silver wire, is stretched along its stem, which, by small wedges prepared for the purpose, and slipped in between it and the bands on which it rests, is always brought into the same position. This being done, the silk thread is turned off, so as to permit the measuring rods to be laid on the standard for comparison. With regard to the smaller chest, such a one was actually made, and sent down to the Heath, towards the close of the operation with the deal rods; but from some mistake in its dimensions, it would not admit the third rod.

Stands for the Measuring Rods. Pl. III. and IV.

6. From the extraordinary levelness of Hounslow Heath, the ascent from the south-east towards the north-west being little more than one foot in a thousand in the distance of five miles, it was easily seen, that the computed base line, or that actually forming a curve parallel to the surface of the sea, at that height above it, would fall so little short of the hypothenusal distance, measured on, or parallel to, the surface of the Heath, as scarcely to deserve notice, had it not been thought necessary to shew, how much one end of the base was really higher than the other; and to convince the world, that in an operation of this sort, where so much accuracy was expected, no pains were spared, nor the most trivial circumstances neglected.

From the trouble and uncertainty attending the frequent use of plummets, especially in windy weather, instead of measuring level or base lines, as has hitherto been customary (in which case it would have been necessary to make use of the plummet, or some

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such contrivance, at every step of ascent or descent) it was judged to be a better method to measure hypothenuses, and, having obtained the relative heights of the stations by the accurate application of the telescopic spirit-level, to compute the base lines. Thus it was proposed, that the length of the base on Hounslow Heath should be obtained by measuring a line through the air, drawn parallel to the common surface from station to station, in equal distances of 200 yards or 600 feet each, and represented in the figure at the top of Pl. III.

For this purpose, two kinds of stands were used; one whose height was fixed, to be placed at the beginning and end of each 200 yards; and the others, whose heights were moveable, that their surfaces might be brought more easily to coincide with the line passing through the air from one fixed stand to the other. The fixed stands in their first state, represented by that towards the left hand in the Plate for the deal rods, were only two feet seven inches in height; but when the glass rods were afterwards used, they had an additional piece of ten inches fastened to the top (as in the left-hand stand of Pl. IV.) which made their total height above the Heath, including the platform on which they stood, three feet and a half. They are tripods of white deal, whose legs extend about three feet from each other; and being braced diagonally, are mortised at top into circles of the same sort of wood. Over this circle, a square table of about $11\frac{1}{2}$ inches is fixed, composed of oak, and mahogany at top; but both taken together do not exceed $1\frac{1}{4}$ inch in thickness.

The nature of the moveable stands, whereof there were at last no fewer than seventeen provided, will be comprehended from the representations of them towards the right hand in Pl. III. and IV. Their general construction, in what regards the part of them which is fixed, differs not from that of the others, excepting that they were of different heights, from two feet to about two feet eight inches, so

as better to suit the irregularities of the ground where it might be necessary to place them. In the middle of each of these, an hexagonal wooden pipe descends, from the top to within two or three inches of the bottom, where it is joined by a brace reaching from each leg. This pipe receives the common cheese-press wooden screw (having three sides screwed and three plane), to the top of which the square table is attached. It is embraced by the circular nut, or winch with four handles, whereby the table is elevated or depressed at pleasure; and being brought to its proper height, is there made perfectly fast by means of the flat-headed iron screw, which passing through one of the legs, presses an iron plate, fixed in the inside of the pipe, against one of the plane sides of the screw.

In describing the deal rods, there has already been occasion to make mention of the vertical and horizontal clamps, whereby the cross feet are fastened to the table on the top of the stand. The nature of these tables will be best understood by consulting the two plans of them towards the right hand in Pl. III.; whereof one represents the two grooves fitted for the alternate reception of the horizontal clamp, according to the side on which the rod lies that is to be moved on into coincidence; and the other shews it actually in its place, with the clamp itself detached in elevation alongside of it. Thus from the plan it may be perceived, that the first, or adjusted rod, lies towards the farther side of the table, and is there secured by the vertical clamp. The second, or moveable rod, lies on the hither side, and therefore the horizontal clamp is placed in the farther groove, where it is firmly pinched by the nut underneath. The rod has been brought to coincidence by working with the two milled-headed screws against the opposite sides of the cross foot. This apparatus, although perfectly good in theory, was found to be much too confined in its nature to answer well in practice, requiring the stands to be placed with a degree of precision, which

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could not be effected in the field without great loss of time; and this was the real cause, as will be seen hereafter, that the measurement by coincidences with the deal rods was given up, and that by contacts adhered to.

Towards the left hand of Pl. III. the plan of one of the square tables is represented with the ends of the second and third rods upon it in contact. In this operation it will be perceived, that only one cross foot of each rod could now rest on and be clamped to the stand, the tables having been inadvertently cut too small to admit of both; and although this has the appearance of imperfection, yet no inconveniency whatever was found to result from it in practice, experience having shewn, that the clamping of either end sufficed to keep the rod steady. Alongside of the table, the vertical clamp, being that now solely made use of, is likewise represented in elevation.

On the face or exterior side of each leg of all the stands, fixed as well as moveable, a plate of brass is screwed near the bottom, with two holes in each, over a groove purposely made in the wood underneath. By means of these plates, parallelopiped leaden weights, about fourteen pounds each, having brass pins with heads suited to enter the holes, and fall down in the grooves, into a narrow-pointed part of them, are readily slipped on or off each leg. Thus every stand, exclusive of its own weight, which is about thirty-one pounds, being loaded with forty-two pounds of lead, is thereby rendered perfectly firm and steady.

A number of wedges were also prepared, and always ready to be placed under the legs; by means of which, and a spirit-level laid on the table, its plane is brought to the proper position.

Notwithstanding all these precautions, it having been found, in the measurement with the deal rods, that time was lost in levelling the stands, particularly in situations where the surface happened to be more than usually uneven, or where it was of a loose or

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spongy nature; therefore Mr. Smeaton advised (and no man's advice is more deserving of attention), that deal platforms, standing on pickets driven into the ground, and properly levelled, should be used to receive the legs of the stands. Accordingly, for the operation with the glass rods (Pl. IV.) twenty such triangular platforms made of inch deal, whose sides were each three feet two inches in length, and void in the middle, were provided; as also a number of beech pickets, about an inch and a half square, and of different lengths, from seven to twelve or fourteen inches. Three of these pickets, short or long as the situation required, being driven into the ground, till their heads (by the carpenter's level) were brought to the proper height, the platform was laid upon them; and on that the stand itself being placed, its position was ultimately corrected by the spirit-level laid on the top of the table. Each of the beech pickets had a hole bored through its top, fit to receive a piece of strong tent-line, by which, and the help of one of the camp mallets, the pickets were easily pulled up again, when the platform was to be removed to a new situation.

Boning Telescope and Rods. Pl. III.

7. In order to trace the line of 200 yards or 600 feet through the air, from one fixed stand to the other, it was usual, in the first place, to stretch a cord extremely tight along the ground, and to divide the space into rod lengths, by small wooden pins placed close by the cord, which remained there, and accordingly marked, very nearly, the points over which the centres of the intermediate stands were to come. A piece of wood, about fourteen inches in length, and one and a half in breadth, painted white, with a narrow black line along the middle of it, being prepared for the purpose, was laid on the surface of the farther stand. The boning telescope, fourteen inches long, and one and a half in diameter, with a small

magnifying power, and moveable object-glass, so as to fit it for very short distances, was then laid on the surface of the nearest stand; which, by means of wedges placed under the legs, had that side towards the farther stand so elevated or depressed, as to bring the cross wires to coincide with the black line on the painted board. Twenty-four boning rods had been originally provided; but it rarely happened, that more than eight or ten of that number were used in any one station. They are of clean deal, upwards of five feet in length, one inch square, and pointed with plate iron at the bottom, so as to be easily fixed into the ground. Each rod carries a cross vane, six or seven inches in length, and three-quarters of an inch in breadth. This cross vane, being moved upwards or downwards along the rod, till its upper surface coincided with the cross wires of the telescope and black line on the painted board, its under surface then marked the height to which the surface of the stand was to be brought at that particular place. In this manner, a certain number of points, in the line passing through the air from one fixed stand to the other, being accurately obtained, it was very easy, at all the intermediate places, by the application of the eye alone to the surface of any one stand or rod, to bring the surfaces of the other stands near it, into the same plane.

Cup and Tripod for preserving the Point upon the Ground, where the Measurement was discontinued at night, and resumed next morning. Pl. III.

8. It has been already mentioned, and, in giving the account of the rough measurement with the chain, there will be farther occasion to remark, that the base was divided into hypothenuses of 200 yards or 600 feet each, where square pickets were driven into the ground, and regularly numbered, so as to be easily referred to on any occasion. In the measurement with the rods, it was

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customary to finish the day's work at or near one of these stations. When the rods of twenty feet were used, the termination of a rod was, of course, always found to be within a few inches of the picket corresponding with the hypothenuse, as determined by the chain. But with the rods of twenty feet three inches, the day's work was always ended with a fractional rod, by suspending a plummet from some convenient part of the stem, marked for the purpose, and which consequently became the point of commencement next morning.

The brass cup, made use of on these occasions, is of the figure of an inverted truncated cone, whose mean diameter is four inches, and its depth about five, with a very small inclination in the sides. It was placed in a hole dug for it in the earth, immediately under the point of suspension of the plummet, serving only to hold the water in which it vibrated.

The nature of the tripod will be best conceived from the plan and elevation of it in Pl. III. It consists of two strong pieces of beech wood, mortised into each other, so as to resemble a half cross, or the letter T inverted, having three strong iron prongs, about twelve inches in length, which pass through the ends of the wood, and are fastened to it by square nuts at top. On the surface of the tripod lies a similar half cross of mahogany, moveable by means of grooves in the direction of the longest side, and fixable by its proper screws, when brought to the desired position. This mahogany half-cross carries on its surface a brass ruler, moveable at right angles to the former direction, fixable also by means of its own screws, and on whose end is cut a very fine intersection. Thus any day's operation having been finished, the tripod was placed near the cup, with its longest side parallel to the line of measurement, and its prongs driven into the ground, so as to be rendered perfectly immoveable without great violence. The plummet being then suspended by a fine gilt wire, at any part of the

stem of the deal rods indifferently, but always at the fixed* or hindermost end of the glass rods, the brass ruler was advanced so near as almost to touch the wire, and there made fast. This being done, the mahogany half-cross was lastly moved backwards or forwards, in the direction of the line of measurement, until the intersection, as seen by a person lying down on the ground for the purpose, accurately coincided with the gilt wire, where it was likewise fastened by its proper screws. A tent was then pitched very near the apparatus, for the soldiers who furnished the centinel for its security, till the measurement was resumed: and particularly to guard it from being disturbed by cattle during the night.

Wheels for terminating, in a permanent manner, the Extremities of the Base. Pl. III.

9. Before any accurate measurement could ultimately be made of the base by means of rods, in order that we might with certainty refer to the same point, on any occasion that might arise of correction or repetition of the work, it had all along been foreseen, that it would be absolutely necessary to sink deep into the ground wooden pipes, or such like things, at the extremities of the base, which could not be removed, or even disturbed, by idle or ignorant people, without very considerable labour. Mr. Mylne, F. R. S. was accordingly requested to order two such pipes to be provided, about six feet in length each, and one foot in diameter, with a bore of four inches in the uppermost end, for the depth of two feet, and cross arms near the lowermost end, in the style of the common warping posts. As an improvement on this idea, Mr. Mylne very

* That this might be conveniently done, a moveable stand was placed, under the glass rod, about four feet from the fixed end, and its table elevated till, by bearing against the lower part of the case, it received its weight. This permitted the stand under the fixed end to be lowered and removed, to make room for the apparatus.

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judiciously proposed that, instead of the cross arms, the lower ends of the pipes should pass through the nave of an old coach-wheel, and then be secured by a bolt underneath. This alteration was approved of; and the machines, thus executed, were sent soon after by water to Hampton.

The plan and section of one of these wheels, with the dished side downwards, are represented towards the left hand in Pl. III. where it will be perceived, that by means of four knee-pieces, made of crooked oak, the pipe is firmly bolted to the wheel, and thereby kept at right angles to its plane. The top of the pipe is also secured exteriorly by an iron hoop, and has a cast-iron box driven into it, whose inner diameter is four inches, answering to that of the bore. Four oak piles for each wheel were prepared to be driven into the bottoms of the pits dug for their reception, which were six feet in diameter, and the same in depth. The soil near Hampton Poor-house being of a loose sandy nature, there the piles were easily driven into the bottom, until their tops were on the same level. The flat of the fellies of the wheel being then laid on the piles, the earth was filled in and well rammed around the pipe, quite up to the surface, with which its mouth is even. But the soil at King's Arbour, being a hard-bound gravel, the piles could not be driven into the bottom of that pit; wherefore, the flat of the wheel rests there on the gravel only.

The brass cup, formerly described, was from the first intended to be placed in the pipes, for which purpose it has two lids; one a semicircle, with the central point marked by a line cut on its diameter, brought into the direction of the base; with which line the gilt wire, suspended at the extremity of the first rod, was made to coincide on the commencement of the measurement. The other lid has a very small hole made in its centre, through which the plummet wire is to pass, when suspended from the centre of the instrument, hereafter to be made use of for the determination

of the angles at the base, or in any other station whatever, where it may be necessary to bring it very accurately over a point on the surface of the ground underneath.

Rough Measurement of the Base with the Chain, and Determination of the relative Heights of the Stations by means of the Telescopic Spirit-Level. Pl. I. and II.

10. Having in the preceding description of the various instruments, originally provided for the measurement of the base, fully explained their constructions, uses, and modes of application: and having thereby anticipated, in a great degree, what must otherwise have been said to make them understood in any account, blended with that of the execution; little more now remains to be given than the journal of our proceedings from day to day, and the ultimate result of the operation.

Mr. Ramsden having produced his hundred-feet chain, with the portable transit instrument; and having lent us an excellent telescopic spirit-level, for determining the relative heights; two sections of the base being likewise cleared by the soldiers, and some progress made in the third, we found ourselves, on the 16th of June, in readiness to begin the rough measurement.

Lieut. Colonel Calderwood, of his Majesty's Horse-Guards, F. R. S. had, from the beginning, been so good as to promise his assistance in the operation. Lieut. Colonel Pringle too, of the Corps of Engineers, obligingly became a volunteer on the occasion; as did also Mr. Lloyd, F. R. S. a few days afterwards; while Ensign Reynolds, of the 34th regiment, who had for some time past been employed in surveying the environs of the Heath, continued that work with such spare hands as could be afforded him for that purpose; and it is to the Plan (Pl. I.) done by that officer, that it will be necessary to refer in any thing regarding

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locality, in what has hitherto been said, as well as in the subsequent relation.

The lower end of the base had for some time past been distinguished by a St. George's flag fixed to the top of a fir spar, thirty-five feet in height; and one of the signal bell-tents still remained at the station near the Summerhouse. A rope of 200 yards being made very fast by a strong iron picket, driven into the ground at the bottom of the flag-staff, the other end was carried on along the base, and placed at the bottom of a camp colour, in a line with the bell-tent. The rope being wound around a strong iron reel, prepared for the purpose, was thereby stretched extremely tight, a person occasionally lifting it up in the middle, or at other places, and letting it drop again, so as to bring the whole into the same straight line. Five persons were necessary for the proper management of the chain; two at each end for its adjustment there, and one towards the middle, to lay it close to the rope, or to bear it up in any particular place, where the circumstances of the ground rendered such precautions useful. The zero or rear end of the chain being strained back, so as to coincide with the point of commencement, a steel arrow was placed as erect as possible in the semicircular cavity of the brass handle at the other end. The chain being then drawn on, till the cavity in the rear handle could be applied to the first arrow, a second was then placed in that of the front handle, and so on, until six chain lengths were thus measured off; which terminating the first hypothenuse, a beech picket, something more than an inch square, and about seven in length, with No. 1. cut upon it, was driven into the ground, till its head was nearly level with the surface. It is however to be remarked, that the sixth arrow of each hypothenuse was constantly left in the ground till the first of the succeeding one was placed, to avoid the error that would have otherwise arisen in applying the rear end of the chain to the picket instead of the arrow.

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In this manner we proceeded on the 16th of June, and in the space of about three hours and a half, completed the first measurement of the south-east section of the base, comprehending the thirteen hypothenuses between the flag-staff and station near Hanworth Summerhouse, the distance being 78 chains, or 7800 feet, making 2600 yards; and the mean temperature of the air being 63°.

On the subsequent day this section was re-measured with equal care, when the total extent fell short of the thirteenth picket only five inches. And here it is to be observed, that a considerable part of this difference probably arose from the stretching of the chain across Wolsey River, at the same time that the irregularities of the ground are greater in this than in either of the other two sections. The mean heat of this day was 65°.

The operation with the chain was suspended during the 18th and 19th of June, those days having been employed in settling certain matters with Mr. Ramsden relative to the deal rods, as well as to give time for the making of a holdfast for the rear end of the chain, invented by Lieut. Colonel Pringle. This machine, whereof the plan at large is represented by dotted lines at the handle of the chain, as it is in small by the two elevations adjoining in Pl. II. consists of a semicircular iron plate, from the bottom of which projects two double and one single prong. In the middle, between two double prongs, a semicircular cavity is formed, fitted to receive the steel arrow on one side, while that in the brass receives it on the other. In a socket in the middle, a strong wooden handle, resembling that of a spade, is placed. Thus the rear handle of the chain being applied to the arrow, the holdfast embraces with its double prongs the straight part of the brass, and in that position, being forced into the ground by the action of a man at the handle, the rear end of the chain is thereby kept so firm as to be immoveable

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by the efforts of the two men at the other end, in stretching it to its true position, for the front arrow.

On Monday, the 21st of June, the operations were resumed, by measuring twice with the chain (forwards and again backwards) the thirteen hypothenuses comprehended in the second section of the base, between Hanworth Summerhouse and the north-west bank of the great Road (an old Roman way) leading from Staines to London. This being the smoothest part of the Heath, and the holdfast being now applied, the two measurements differed only one inch and a half in the distance of 7800 feet. This instance of accuracy is alone sufficient to prove the great excellence of the chain, although another will be given hereafter still more surprising.

On the same day that the second section of the base was measured, the levels of that and the first were taken. The operation of levelling is so universally known, as to render any detail of it unnecessary. It will be sufficient to say, that the spirit-level made use of on this occasion was a very good one, about eighteen inches in length, and could at all times be very readily and accurately adjusted, by inversion in its Y's. The tops of the pickets, marking the hypothenusal distances, were the points on which the levelling rods were placed on each side of the level; which being inverted at the intermediate picket, points equidistant from the centre of the earth were thereby obtained at the cross vanes of the levelling rods, and no correction for curvature or refraction necessary. It will be readily understood, that the relative heights of the pickets were found by measuring their distances from the centres of the cross vanes and axis of the telescope respectively.

The six first columns towards the left hand of the first or general table subjoined to this Paper, shew distinctly every thing relating to the levels of the whole base, those of the third section having been determined on the 22d of June. By examining the table it

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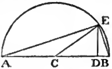
will be seen, that the ascent on the first section is	10.555 feet,
on the second - -	8.580
and on the third - -	12.130
Total - - - - -	31.265 feet,

between the lower extremity at Hampton Poorhouse, and the higher near King's Arbour.

The computed numbers in the seventh column are the reductions * depending on the aforesaid heights, or the differences between the hypothenusal distances of 600 feet each and the reduced base distances. With regard to the remaining columns of the table, or those towards the right hand, they will be severally spoken to hereafter, in taking into consideration the expansion of metals, as determined with great accuracy by the experiments with the pyrometer.

Hitherto no use had been made of the transit instrument: for, in order that it might be applied to advantage, there was a necessity for laying the wheel into the ground at the lower end of the

* The reduction in the seventh column, I have computed by the difference between the square of the hypothenuse, actually measured, and the square of the height found by the level; and Lieut. Col. Calderwood has done the same thing by a much shorter method. Thus, in the annexed figure, CE being the hypothenuse of 600 feet, DE the perpendicular height obtained by levelling, DB the reduction required, or the difference between the hypothenuse and true base; then, substituting the chord BE instead of DE, the following analogy is



obtained; AB : BE :: BE : DB; consequently, $\frac{BE^2}{AB} = DB$: that is, the square of the perpendicular height being divided by double the distance, or 1200 feet, the quotient is equal to DB the reduction, without sensible error. For if DE were four feet, the greatest perpendicular height in the base, BE the chord would only exceed it [illegible], which would not be more than [illegible] part of an inch. The difference between the results, by the two modes of computation, is so trifling as not to deserve notice.

base, and so to modify the St. George's flag-staff that, being placed in the pipe, it might be steadily supported by braces in a true vertical position; which we found, from experience, could not be effected by ropes only.

The wheel being accordingly laid in its place, and the other precautions taken for securing the flag-staff, which was likewise painted white, that it might be more distinctly seen from the farther extremity; on the 22d of June, the transit instrument was adjusted over the thirteenth picket at Hanworth Summerhouse, while directed upon the flag-staff. But it being now found, that the vertical plane passing through the flag-staff fell to the eastward of the centre of Bansted Spire, therefore the transit was gradually moved to the eastward, until by repeated trials the three points were perceived to be in the same vertical plane, when the picket was moved, and replaced exactly under the axis of the telescope, a few inches from its first position. The same operation was repeated at the twenty-sixth station, on the farther bank of the Staines Road; and, lastly, at the forty-sixth, forming the north-west extremity of the base; where a pit was immediately dug for the wheel, which was placed therein, without however filling in the earth for the present, that being deferred till near the completion of the measurement with the deal rods. Thus the two extremities, and two intermediate points of the base, being accurately placed, by the help of the transit instrument, in the same vertical plane with Bansted Spire, it was easily seen, that by arranging camp colours in the intervals at any time, all the other points might be brought so nearly to coincide with these first, as not to occasion, by deviation, any sensible error in the measurement afterwards to be made. This application of the transit shewed us, however, that some labour had been lost by not using it sooner: for at the Staines Road, the tract cleared by the soldiers deviated about two feet and a half too much to the westward for the true line; and at King's Arbour it was twice as

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much: so that we were now obliged to widen the cleared tract, by adding to the eastern side of it.

On the same day that the chief points in the base were fixed by means of the transit, and the levels of the third section taken as before mentioned, the rough measurement of that section with the chain was completed, and found to contain nineteen hypothenusal distances of 600 feet each, and one of 404.55, making in the whole 11804.55 feet, between the twenty-sixth station at the Staines Road and the centre of the pipe near King's Arbour, the mean temperature being $62°\frac{1}{2}$. Here it is to be observed, that this last section was only measured once with the chain, the tract not being yet sufficiently cleared to admit of its being done to the best advantage; and, when completed, it was judged to be better to proceed directly in the operation with the rods, than to lose time in the usual repetition, since the merits of the chain, in this way of applying it, were already sufficiently well established; and any future tests to which it was to be put were proposed to be of a more rigid nature.

When the length of the chain, in its original state, was ascertained by the dots on the brass pins in the New England plank, it was found, in the then temperature of 74°, to exceed the 100 feet by near one quarter of an inch, or 0.245 inch. Therefore, in the temperature of 63°, being that in which the lengths of the deal rods were laid off, and differing very little from what was likewise the meant heat of the air, when applied upon the Heath, the chain, according to the experiments on the expansion of the very same steel, would exceed the 100 feet by 0.161 inch, or 0.0134 foot. Hence the sum of the three sections of the base, 274 chains, being multiplied by 0.0134 foot, we shall have 3.67 feet for the equation of the chain + 4.55 feet, to be added to its length, which will then become 27408.22 feet from the centre of one pipe to the centre of the other: and this would have been the true length of the base, as given by the rough measurement with the chain, if the surface had

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been one uniform inclined plane throughout its whole extent. But, although the ascent of Hounslow Heath is so small, and so gradual, as to occasion little more than half an inch of reduction, from the 46 hypothenusal to the 46 base distances, into which it is divided, as may be seen by referring to the table ; yet each of these hypothenuses containing again many other small irregularities, all of which affect the measurement by the chain, in proportion to their number and height, in every space of 600 feet, their united effects, including the lateral deviations from the true line in measuring, do somewhat more than compensate for the extra-length of the chain, as will be seen hereafter in comparing the length of the base just now obtained with that given by the rods.

The weather, which during the greater part of June had been wet, became still worse towards the end of the month and first week of July; so much so, that even if the deal rods had been ready, they could not have been used with advantage. The soldiers, nevertheless, were not idle, being, when the weather would permit, partly employed in clearing the Heath, and partly in assisting Mr. Reynolds in the survey, towards the perfecting of which many chief points were fixed by means of my astronomical quadrant, placed for that purpose at several different stations of the base. At this time too (July 8th) I levelled from the lower end of the base to the surface of the Thames at Hampton, and found the descent to be 36.1 feet.

Measurement of the Base with the Deal Rods. Pl. I. and III.

11. Such extraordinary care and pains had been bestowed in the construction of the deal rods, in order to render them the best which had ever been made, that, although begun early in June, they were not completely finished before the 15th of July. They were brought that afternoon by Mr. Ramsden, together with the

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various parts of the apparatus necessary for their application in the field, to the camp, now moved from Hanworth Summerhouse to the intersection of the base with Wolsey River; whence they were transported, early next morning, to the pipe near Hampton Poorhouse, where we were met by Sir Joseph Banks, accompanied by Mess. Blagden, Cavendish, Lloyd, and Smeaton, all ready to lend their assistance in the subsequent mensuration.

Before I proceed farther, I think it here incumbent upon me very gratefully to remark, that the respectable and very worthy President of the Royal Society, ever zealous in the cause of science, and who had repeatedly visited the Heath, to offer aid, if such had been necessary, while the first and rougher part of the operations were going on; now, that others of a more delicate nature were to commence, and where it was of importance, that those entrusted with the execution should meet with as few, and as short interruptions as possible, not only gave his attendance from morning to night in the field, during the whole progress of the work; but also, with that liberality of mind which distinguishes all his actions, ordered his tents to be continually pitched near at hand, where his immediate guests, and the numerous visitors whom curiosity drew to the spot, met with the most hospitable supply of every necessary and even elegant refreshment. It will easily be imagined, how greatly this tended to expedite the work, and how much more comfortable and pleasant it rendered the labour to all who obligingly took part in it; but more especially to him, who, being a volunteer in it at first, considered himself as bound to persevere in his best endeavours to bring it to a successful conclusion.

From the description that has been given of the deal rods, it will be remembered, that they are fitted to be applied in measuring, either by the coincidences of lines, inlaid one inch and a half

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from each extremity, or by the contacts of the spherical lips of the bell-metal with which they are tipped. The first, seeming to be the most accurate, although the most tedious method, was that by which we proposed to set out.

The flag-staff having been previously removed from the pipe, and the brass cup filled with water put in its stead, all the necessary precautions being likewise taken for preserving the line of direction, horizontally, by the rope stretched along the first hypothenuse, and vertically, by means of the boning rods; the first ivory line on the first rod was brought by the plummet to coincide with the centre of the cup, in which position, being clamped, it accurately marked the commencement of the base. The second rod being now applied to the first, and moved up by the apparatus formerly described (Pl. III.) till its line coincided with that on the first; and, in like manner, the third rod being applied on the alternate side of the second, moved up and clamped as the rest; thus the exact distance of sixty feet was ascertained; care being always taken, that the first adjustments were not disturbed, while the subsequent ones were forming. The clamps fastening the first rod to its stands being then detached, it was carried by two men and laid on the alternate side of the third; and so on in succession, until fifteen rod lengths were measured off, being the half of the first hypothenuse.

The time consumed in measuring this short distance of 300 feet was not less than five hours; owing, as has been formerly mentioned, to the confined nature of the apparatus for moving the rods on into coincidence, which required such nicety in placing the stands, as could not be effected until after several repeated unsuccessful trials. All the executive people were therefore of opinion, that it would be proper to discontinue this mode of measurement, at least until a more convenient apparatus could be thought of for the purpose; and that, in the mean time, we should

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proceed by the method of contacts, as the only alternative we could for the present adopt.*

The rods being accordingly placed in contact with each other, we soon made greater progress, finishing the operations of the day at the middle of the fourth hypothenuse, where the tripod, with its guard, was placed, to preserve the point of commencement for the ensuing morning.

The measuring rods, when put into the chest in London, had been compared and found to agree with the standard. The comparison was not repeated on the 16th; but this being done on the 17th, at 7^h A. M. under the oil-cloth canopy at the camp, they were found at a medium to exceed the standard by one-fiftieth of an inch, the temperature then being 62°. After the comparison they were carried to the place of the tripod, when the operation was resumed by bringing, with the help of the plummet, the same point of the rod with which we had left off work, to coincide with the intersection on the brass ruler. The measurement of this day was closed at the end of the tenth hypothenuse, when the rods being carried back to camp, were compared, and found accurately to agree with the standard.

A considerable fall in the barometer, between the evening of

* Although I acquiesced in the change thus become necessary, yet it was with much reluctance, because it left undecided the contested point, with regard to coincidences and contacts. If we could have proceeded with the coincident rods till eighty-one lengths were measured off, and then measured back the same space by placing eighty rods in contact, the point would have been clearly settled. For if the termination of the eightieth rod agreed exactly with the point of departure, contacts being the most expeditious would have been judged the best method. On the contrary, if the eightieth rod fell short of reaching the point of departure, there could have been no doubt, that the difference must have arisen from butting one rod against the other, whereby a certain small proportion of each rod came to be lost in the account, by being measured twice over.

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the 17th and the morning of the 19th, portended rain. Nevertheless, all parties repaired to the place of rendezvous, which was appointed at the lower end of the base, in order to remeasure the two first hypothenuses, by placing all the rods in contact, which on the 16th had been done partly one way and partly the other. The operation being accordingly repeated with great care, the point of the sixtieth rod, which formerly corresponded to the centre of the second picket, was now found to be pushed forward exactly forty-five inches, answerable to the deficiency on the fifteen coincident rods, with which the mensuration was begun. It now began to rain, therefore the rods were carried back to camp, and being severally compared, they were found to exceed the standard each by one-thirtieth of an inch, occasioned by the extraordinary humidity of the air. A heavy rain ensued; and what made this much more regretted by all, was, that in the forenoon their Majesties graciously condescended to honour the camp with their presence, and continued there some time; but the weather becoming rather worse, it was utterly impossible to shew their Majesties the nature of the operation, by any progress that could at that time be made in the work.

After a continuance of unfavourable weather for several days, the operations were resumed at 9^h A. M. of the 23d, when the rods being compared, were found still to exceed the standard by one-thirtieth of an inch, and the temperature now was 61°. Here it is to be observed, that in our progress forward, an accurate register had been all along kept of that point of each rod corresponding to the centre of the hypothenusal pickets, by noting its distance from either end, whereby the error of the chain at each station was readily discovered, at the same time that the revolutions of the three rods served to keep the account of the total measurement. In order, therefore, that this method might be distinctly adhered to, it was judged proper to push on the rod that lay over the

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tripod at No. 10. exactly forty-five inches, to make good the deficiency of the first fifteen coincident rods, and that the account might be kept from the lower end of the base in entire rods of 243, and complete revolutions of 729 inches each. This being done, the rest were placed in the ordinary succession; and we finished the business of the day at the eighteenth station, where the rods being compared at 6^h P.M. their mean length was found to exceed that of the standard $\frac{1}{67}$th part of an inch, the temperature then being 54°.

On Saturday the 24th of July, the rods were three times compared; at $7^h\ 30'$ A.M.; $11^h\ 15'$ A.M.; and $5^h\ 45'$ P.M. Their mean excess above the standard was found to be one-thirtieth of an inch, and the mean heat 64°. In the course of the day, the measurement was continued from the eighteenth to the twenty-seventh station, or first of the third section of the base, where the tripod was placed as usual; and there it remained untouched, on account of bad weather, till Monday the 2d of August.

Considering how much time and labour had been bestowed in obtaining what we certainly had every reason to conclude were the best deal rods that ever were made, it was no small disappointment now to find, that they were so liable to lengthen and shorten, by the humid and dry states of the atmosphere, as to leave us no hopes of being able, by their means, to determine the length of the base to that degree of precision we had all along aimed at. But since more than one half of it was already measured, it was judged proper to proceed with them in their present state, and then to have them carefully painted or varnished, before they should be farther used.

The unfavourableness of the season, and delays in obtaining the instruments, had already been the causes of protracting the operations on Hounslow Heath greatly beyond what was at first expected; and the failure of the deal rods gave no immediate pro-

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spect of their being speedily brought to a conclusion. On revolving in my own mind the different alternatives we might ultimately be obliged to have recourse to, metal rods of some kind or other, whose expansion could always be determined by experiment, seemed to promise a result that might be safely relied on. Cast iron was what I had thoughts of proposing, knowing, from an experiment which I had made myself, that it expanded less than steel. The cumbersomeness of its weight appeared indeed objectionable; but that inconvenience was either to be submitted to, or one of another kind, namely, the reduction of the length, which was always, if possible, to be avoided.

At this time Lieut. Colonel Calderwood could not conveniently lend us his assistance in the field; but he visited us occasionally, and on one of these visits proposed to me, that glass rods should be made use of instead of deal; putting me in mind of another experiment * that I had made, which seemed to shew that solid glass rods expanded less than tubes. This proposition the Lieutenant Colonel, before he came to the Heath, had made to Mr. Ramsden, who appeared averse from making the trial, because of the great length of the rods, and the brittleness of the material. Nevertheless, it being sufficiently obvious, that glass rods or tubes of the full length, or something approaching towards it, would be much

* The experiment here alluded to was made with Mr. Cumming's pyrometer, which from its construction did not admit of a very accurate estimation of the heat communicated to the standard bar, the rod, and tube respectively. Either, therefore, the natures of the glass rod and tube, made use of at that time, must have been very different, to cause the difference of expansion; or some circumstance in the instrument unattended to, had occasioned the fallacious appearance: for it will be found, from the experiments hereafter to be given in detail, that a solid glass pendulum rod expands fully as much as, nay, in this particular instance, even more than a tube; but different glass, having different specific gravities, will no doubt be susceptible of different degrees of expansibility.

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sooner provided than any metal rods whatever, and the saving of time being a point of consequence; Lieut. Colonel Calderwood was accordingly requested to make the trial at the glass-house, as soon as possible after his return to town. Next day he succeeded in getting a fine tube drawn, eighteen feet long, and about one inch in diameter; and there seemed to be no longer any doubt, that those of the proper length might be obtained. It was found, that solid glass rods of such extraordinary dimensions could not be had, it being impossible to take at once a sufficient quantity of the melted metal on the irons, made use of for drawing them at the glass-house.

The week of rainy weather, which ended the month of July, occasioning, as has been said, a total suspension of the operations on the Heath, was employed in procuring a sufficient number of glass tubes (one whereof was not less than twenty-six feet long) and regulating with Mr. Ramsden every thing concerning their construction into measuring rods. The description of them we shall however defer until the time of their application in the field, after having finished the operation with those of deal.

On Monday the 2d of August, the operations on the Heath were resumed at 8^{h} 30′ A. M. by comparing the rods with the standard, which they were found to exceed by one-fortieth of an inch, the temperature then being 66°. The forward end of the rod now placed over the tripod at No. 27, completing the 800th length, reckoned from the lower end of the base by rods of 243 inches each; and these being equal to 810 rods of 240 inches; it was judged proper to mark a point upon the ground corresponding to this forward end, that it might be referred to in returning back with the measurement by the glass rods. This was done by sinking two small pickets into the ground, about a foot asunder, one on each side of the base, and at right angles to it. A silk thread being then stretched over the tops of the pickets, and gently

moved on till it touched the silver wire suspended from the end of the rod, fine notches were then made with a pen-knife in the tops of the pickets, whereby the thread could be replaced in the same situation; which being done, the pickets were covered over with earth. In the course of this day nine hypothenuses were measured; and at 7^h P. M. the tripod was placed at the thirty-sixth station. The rods, being now compared, were found to agree with the standard; and the temperature was $67^{\circ}\frac{1}{2}$.

On Tuesday the 3d of August, the rods were compared at 7^h A. M. and found only to exceed the standard by one-sixtieth of an inch. Being arrived at the middle of the forty-first hypothenuse, a point corresponding to the forward end of the 1215th rod was transferred to the ground, by the double pickets and silk thread, as had been done at the twenty-seventh station. The measurement was then continued to the north-west extremity of the base, which was found in the whole to contain 1353 complete long rods of 243 inches each + 21 inches, where the tripod was placed, in the point which of course corresponded to the 1370th short rod of 240 inches each, equal to 328800 inches, or 27400 feet. To which distance we have yet to add 4.31 feet, being the space intercepted between the intersection on the tripod and the centre of the pipe marking the north-west extremity of the base; whose total length, as given by the deal rods, without regard to expansion, or reduction of the hypothenusal line, becomes 27404.31 feet. And here it is to be observed, that the intersection on the tripod terminating the 27400 feet only overshot the picket answering to the 274th chain by two inches and nine-tenths. But this nice agreement between the result by the deal rods, and that furnished by the rough measurement with the chain, arises from the extra-length of this last, which so nearly compensated for all the irregularities of the surface.

The measurement with the deal rods being finished, they were

compared at 5^h P.M. and found to agree with the standard, the temperature then being $75°$.

Expansion of the Deal Rods.

12. It has been an opinion generally enough, although, as we have seen, erroneously received, that very straight fibred deal was not at all, or but little, affected longitudinally by the humidity of the air. That we might not be led astray by trusting to fallacies of this sort, the standard rod had been provided; which being always closely shut up in its chest, except during the short interim of comparison, could feel but a small proportion of the effects which the measuring rods suffered; these being constantly exposed to the open air throughout the day, as well as to the moisture of the night, when lying under the oil-cloth canopy. The standard rod, it is true, could not be accurately compared with the brass scale: for although, when constructed, brass pins, forty inches asunder, had been driven into its stem, for the purpose of such comparison, yet these had afterwards been displaced, or at least the points upon them defaced, by the plaining over of the upper surface. This circumstance, which was unattended to when the operations commenced, is now of no consequence; because, from an experiment hereafter to be mentioned, the lengthening of the standard may be pretty nearly ascertained. But since there are some contradictory circumstances, soon to be mentioned, in the operation with the deal rods, which would have made a repetition of it absolutely necessary, if we had not now obtained those of a different kind, so very unexceptionable in their nature and mode of application, as, in the present case, to admit of no competition between the two results, and to render it improper on our part ever to havė farther recourse to the first; so there can be little doubt, that deal rods will be universally rejected by other

countries, in any measurements they may have occasion to make in future.

About the 10th of July, two rods, one of New England and the other of Riga deal, being measured by the fixed points in the great plank in Mr. Ramsden's shop, and having each two brass pins driven into them at the distance of twenty feet, were laid on the top of the house, where they remained until the 26th, the weather, for the greater part of the time, having been very wet. They were then taken down, and being, by means of the long beam-compass, compared with the measures on the plank, the New England rod was found to have lengthened 0.031 inch, and the Riga rod 0.041 inch. By which experiment the fact seems to be established, that Riga red wood, notwithstanding the quantity of turpentine which it contains, is more susceptible of the effects of moisture than New England white wood. Mr. Ramsden likewise finds, that the great plank so often mentioned, suffers, in ordinary summer weather, an alternate expansion and contraction, amounting at a medium to 0.0041 of an inch every day: that is to say, if the distance between the twenty-feet brass points be measured from the scale, by means of the beam-compass, in the evening, it is found to have lengthened next morning 0.0041 of an inch, by the humidity of the intervening night. In the course of the following day it contracts again to its former length, and so on. Mr. Ramsden has often observed this alternate change in the deal plank; but it was particularly on the 11th and 12th of August, that the quantity was actually measured. It will readily be understood, that any difference of temperature which might have happened in the brass scale, at the times of comparison, was always carefully taken into the account.

Now, from this last experiment, it seems probable, that we shall not be very wide of the truth in supposing, that the standard deal rod, which lay closed up in its chest, under the canopy on Houn-

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slow Heath, would suffer the same sort of alternate expansion and contraction with the abovementioned plank; that is to say, being of Riga wood, its mean expansion about the middle of the day would be $\frac{25}{10000}$ of an inch. By this quantity then we must augment the actual observed expansion of the measuring rods, in order to obtain within certain probable limits (since we cannot determine it accurately) the equation for the expansion; or that space by which the apparent measurement, given by the 1370 deal rods, should be augmented, in order to obtain the true length of the base; or that which would have been given by unalterable rods, of the same original length with those of deal, as expressed in the following table.

Table of the Expansion of the Deal Rods.

Days.	Nº of rods meas.	Hour of comparison.	Temp. of the air.	Observed expansion.	Decimal mean.	Equation for the meas. rods.	Equation for the standard.	Total expansion.
		h. ′	°	In.		In.	In.	In.
July 16	105	4 0 A.M. 6 0 P.M.	48 62	$\frac{1}{50}$th 0	0.010	1.050	0.2625	1.3125
17	195	7 0 A.M. 6 0 P.M.	62 —	$\frac{1}{50}$th 0	0.010	1.950	0.4875	2.4375
23	240	9 0 A.M 6 0 P.M.	61 54	$\frac{1}{40}$ $\frac{1}{57}$	0.021	5.040	0.6000	5.6400
24	270	7 30 A.M. 11 15 A.M. 5 45 P.M.	61 66 64	$\frac{1}{28}$ $\frac{1}{31}$ $\frac{1}{33}$	0.033	8.910	0.6650	9.5750
Aug. 2	270	8 30 A.M. 7 0 P.M.	66 $67\frac{1}{2}$	$\frac{1}{40}$ 0	0.0125	3.375	0.6650	4.0400
3	290	7 0 A.M. 5 0 P.M	56 75	$\frac{1}{30}$ 0	0.017	0.493	0.7250	1.2180
Total	1370	– –	–	–	–	20.818	3.405	24.223

N. B. Although the rods were not compared with the standard on the 16th of July, yet the expansion probably was, and therefore has been estimated, at the same rate as it was found on the following day.

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By examining the preceding table, it will appear, that the total expansion of the 1370 deal rods, including the small equation for the lengthening of the standard, amounts to 24.223 inches, or 2.02 feet; which being added to the apparent length of the base 27404.31 feet, formerly obtained, we shall have, for the hypothenusal length, 27406.33 feet: and from this deducting 0.07 foot, the excess of the hypothenusal above the base line, or the reduction contained in the seventh column of the general table of the base, there will remain 27406.26 for the distance given, by the deal rods, between the centres of the pipes terminating the base, reduced to the level of the lowest, or that at Hampton Poorhouse, in the temperature of 63°, being that of the brass scale when the lengths of the deal rods were laid off. All this, however, supposes three things to be absolutely certain: first, that the expansion of the rods has been accurately estimated; secondly, that no error has arisen from the butting of the rods against each other, in order to bring them into contact; and, thirdly, that no mistake of any kind has been committed in the execution. When we come to give the true length of the base, as ultimately ascertained by means of the glass rods, it will appear, that one or more of these three have actually taken place; although it is most probable, that only the two first sources of error have contributed their share of the total difference between the two results. But the discussion of this point must be deferred for the present; and I shall now finish the subject of the expansion of the deal rods, by mentioning two other comparisons of them, which serve to shew still more obviously, how improper they are for very accurate measurement!

It has already been remarked, that the last week of July was so wet as to occasion a total suspension of the operations on Hounslow Heath. On the 26th of that month, at 8h A. M. the temperature being then 63°, the rods were compared with the stan-

dard, and found to exceed it, at a medium, one-fifteenth part of an inch. Now, if we suppose the whole base to have been measured with the rods in that state, the difference would have amounted to more than $7\frac{1}{2}$ feet, exclusive of what the standard itself might have altered from its original length.

The other comparison was made at Spring Grove, in the beginning of September, after our operations on the Heath had been finished, and the deal rods with their apparatus deposited under the roof of Sir Joseph Banks's barn. The object here in view was the measurement of such a space as the garden would conveniently admit of, when the rods were in their dry or contracted state; and to re-measure the same space next morning, when the rods, being left out for the purpose, had imbibed all the humidity they could from the moisture of the intervening night. Accordingly, the fourth being a fine dry day, the sun shining bright, and the thermometer about 68°, seventeen stands were arranged in the long walk, with so much nicety in the same inclined plane as to appear but like one. The first or lowermost stand had a brass cock screwed to its top. The two uppermost, that is to say, the sixteenth and seventeenth, were of the fixed kind, each with a brass slide, and placed only forty-five inches asunder. The first deal rod was made to butt against the brass cock, and the rest successively against each other, until fifteen rod lengths were measured off, and a fine line drawn on the slide marking the extremity of the fifteenth. That rod being removed, forty-five inches, taken from the brass scale, were then laid off backwards from the line on the slide of the seventeenth to the slide of the sixteenth stand, where another fine line was drawn. Thus the space comprehended between this last line and the cock on the first stand, was just 300 feet, or fifteen coincident rods. During the night of the 4th, which was very fine, the rods lay on the smooth grass. About sun-rising of the 5th there came on a thick fog, which

entirely dispelled about 8 o'clock. At 7^h A. M. the rods being lifted from the grass, it was perceived, that the under sides were perfectly dry, while all the rest was quite wet with the dew that had fallen. The fourteen stands, comprehended between the first and sixteenth, having their distances gradually reduced from twenty feet three inches to twenty feet, the operation of re-measurement was then begun, by placing the rods in coincidence with each other (which was now found to be easily and accurately effected by a few repeated strokes with a wooden wedge only) until the fifteen rod lengths were measured off, and a fine line, corresponding with the ivory on the fifteenth, was drawn on the brass slide. This line was found to be $0.\frac{498}{1000}$, or near half an inch beyond that which terminated the 300 feet the preceding evening. Hence it is evident, that the dew imbibed only in one night, or a space of time not exceeding fourteen hours, occasioned such an expansion in the deal rods, as in the whole base would have amounted to 45.484 inches.

It is sufficiently obvious, that this last mentioned experiment was more accurate, in the proportion of about fifteen to one, than any comparison we could at that time have made with the standard. But since immediately after it was finished, the sun shone out very bright, it is by no means certain, how soon the rods would again have contracted to their former length, or near it, had they been exposed to his rays. Repeated comparisons for ascertaining facts of this sort, at very short interims, are absolutely incompatible with the nature of such tedious and troublesome operations as the measurement of long bases: and here, indeed, lies the great objection to the use of deal rods, that at no time can we be certain how soon, after a comparison has been made, they may alter their length in a proportion, and sometimes too even in a sense, different from what was expected.

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Description of the Glass Rods, ultimately made use of to determine the Length of the Base. Pl. IV.

13. It has been already mentioned, that the week of rainy weather in the end of July was employed in providing the glass tubes, and in concerting matters with Mr. Ramsden, relative to their construction as measuring rods. Notwithstanding their great length, they were found to be so straight that, when laid on a table, the eye, placed at one end looking through them, could see any small object in the axis of the bore at the other end.

The nature and construction of the glass rods, whereof three were finished for the operation, will be best conceived by considering, with care and attention, the plans and elevations of them, in whole or in part, to different scales in Pl. IV. where likewise may be seen, plans and sections of the ends of the tubes, in their real dimensions, for the better understanding the several parts of the apparatus placed therein.

The case containing the tube, and which serves to keep it from bending in its original straight position, is every where of the depth of eight inches, of the same width in the middle, and tapers from thence, in a curvilinear manner, towards each end, where it is only two inches and a quarter broad. It is made of clean white deal, the two sides being half an inch, and the top and bottom three-eighths in thickness. These last are placed in grooves fitted to receive them, about half an inch from the upper and lower edges of the sides, which bending easily, and applying closely, are then firmly fastened by two rows of wood screws on each side, to the top and bottom respectively. Thus, the depth of the sides in one sense, and the spring which they have by bending in the other, act as trusses, prevent the case from warping, and render it sufficiently strong, although at the same time, considering its great length, very light.

The plan of the middle rod represents the case with the top off, that the tube may be seen placed therein: the right and left-hand rods have the tops on, whereby may be seen the oval opening in the middle of each, shut by a mahogany lid; and also the positions of the two thermometers, with tubes bent at right angles, so as to place the ball about two inches downwards within the case, for the better ascertaining the temperature of the glass, as will easily be conceived, by considering the representation of the tube and ball in the section across the middle of the rod.

It is to be observed, that the middle of the tube is made fast to the middle of the case in the following manner. First, around the middle of the tube, a quantity of packthread, immersed in liquid glue, was wound by several returns on itself, for the space of about two inches in length; and upon this mass of packthread, while the glue was warm, a strong mahogany collar was forced; whereby the three substances became so perfectly united to each other, that they might be considered as one only. Across the bottom of the case in the inside, three mahogany braces or girders, one in the middle, and one half way between it and each end, are fastened, by means of screws, to the bottom and sides. These rise about 1½ inch above the bottom, so as to place the axis of the tube, when in use, about 2½ inches above the surface of the stands on which it rests. The end-pieces of the case are likewise of mahogany, about 1¼ inch thick. Each consists of two parts, a lower and an upper. In the lower parts, as well as in the cross braces, there are semicircular cavities lined with broad cloth, fitted to receive the diameter of the tube, which rests in them, and is consequently supported at five different points. The upper end-pieces, having likewise semicircular cavities fitted to embrace the upper part of the tube, slip down upon it, when it has been, by repeated trials, brought to its true position; that is to say, the axis of the bore into the same straight line, the case

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being all the while supported by its extremities on two stands only, in the manner in which the rods are applied in actual measurement. The braces within the case have also their upper pieces, which, in like manner, apply closely to the tube, and are fixed to the lower ones by means of screws. The whole together serve only as stays to keep the tube in its true place from shaking; but without binding it, however, too closely. Lastly, the mahogany collar glued to the packthread on the middle of the tube, being strongly fixed by four screws to the middle brace, as may be seen in the section, is that by which the tube is kept perfectly immoveable with respect to the middle of the case; while it is unconfined longitudinally in the cavities lined with broad cloth every where else.

Both ends of the tube are ground perfectly smooth, and truly at right angles to the axis of the bore. That end, which in measuring usually lies towards the left hand (since most people will work the screw with the right) projects about seven-tenths of an inch without the case, and is called the fixed end, because the apparatus belonging to it is fixed. The other end towards the right hand projects about nine-tenths of an inch, and, having a moveable apparatus, is called the moveable end.

The fixed apparatus consists of a cork about three inches in length, made of the very best material, and so nicely fitted to the bore, as just to admit of being forced into without bursting it. In the middle of the cork a cylindrical brass tube is placed, whose sides are thin, the inward end thick, and the outward end open. It receives a steel pin, whose inward end being formed into a screw, is thereby fixed into the thick metal of the tube. The steel pin carries outwardly a button and neck of bell-metal. The neck fits so very closely the open end of the brass tube as to prevent any shake there; at the same time that the inside of the button applies very justly to the ground end of the glass

tube, to which the outward surface (being a true plane) is exactly parallel.

The moveable apparatus consists, like the other, of a cork and brass tube of the same length. Before the insertion of this cork, an oblong piece seven-tenths of an inch long, and two-tenths broad, was cut from it, in that part of its cylinder answering to the upper part of the outward end of the glass tube, on the inward surface of which, about half an inch from the end, a fine line had been previously cut by a diamond point. The brass tube in this cork contains within it a loose steel worm, or helical spring, something less than the interior diameter of the tube. Along the cavity formed by the spiral, there passes a steel pin, like that in the fixed end; but it is longer, and has no screw at the inward end, that being nicely ground, so as to fit a circular hole in the inward end of the brass tube, while a triangular bell-metal neck fits one of that figure in the outward end. Thus the pin moves freely backwards or forwards without any shake, and presses upon the steel spring, by means of a circular brass collar, placed for the purpose, at the inward end of the neck; while the outward end is attached to a bell-metal button. The outward surface of this moveable button is spherical, described on a radius of about two inches; while the inward surface, like that at the fixed end, would apply closely to the ground end of the glass tube, but should not be pushed so far forward as to touch it. A circle and narrow slide, cut from a solid cylinder of ivory, fitted originally to enter easily the glass tube, is attached to the inside of the button by small screws, and permits the neck to pass through a hole made on purpose in the circle. The slide is about eight-tenths of an inch long, and has a fine intersection cut upon it near the inward end, made black to render it more conspicuous. Thus, two rods being brought into contact, and the fixed button of one being pressed against the moveable button of the other, the inter-

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section is thereby pushed forwards until it coincides with the diamond line on the interior surface of the tube; whose length is so adjusted, as that, when the coincidence is perfect, the distance between the plane surface of one button, and the spherical surface of the other, is exactly twenty feet. The left-hand side of the plate represents the relative positions of the extremities of the first and second rods, when the ivory is in coincidence with the diamond line. And the right-hand side shews the relative situations of the extremities of the second and third rods, before the ivory is brought to coincidence with the diamond line, the slide being then pushed out by the action of the spiral spring within the cork.

Every rod has four wheels, two at each end. They are two inches in diameter, and connected by a common steel axis, which rises and falls in a vacuity prepared for its admission in the mahogany end-pieces, the under part of which vacuity is afterwards filled up.

A brass strap or bridle, about eight-tenths of an inch broad, passes over the top of the case, and descending down each side, bends outwards, so as to form a projection for the reception of the wheels, whose pivots turn in, but near to the lower end of the bridle, which is kept in its place by means of the two side screws working in grooves, and the milled-headed screw at top. This last serves likewise to raise or depress the wheels at pleasure.

Each rod has two cross feet, placed immediately behind their respective pair of wheels, extending outwards about $4\frac{1}{4}$ inches from the centre on each side. Under their outward extremities, small pieces of hardened steel, formed into the teeth of a file, are fixed by means of screws. When the first rod has been laid in its true place, by unscrewing the milled heads, the wheels are suffered to rise; whereby the whole weight is removed from them, and thrown upon the teeth of the files, which then indent themselves

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into the surface of the stand, and become as it were united to it. But when the fixed button of the second rod is brought to press against the moveable button of the first, the weight being then thrown upon the wheels by screwing the milled heads at top, the rod is easily moved on by the following apparatus.

The three rods are numbered, as were those of deal, 1.2; 3.4; 5.6. On the first or odd end of each rod 1. 3. and 5. there stands a brass fork, about two inches high, fixed by four screws and an oblong plate to the top of the case. On the second, or even end of each, 2. 4. and 6. there stands a brass pillar, of the same height with the fork, likewise fixed to the top of the case by four screws and a circular plate. Two steel rods or hooks were indifferently used for bringing up the moveable rod (the weight then lying on the wheels) into its true place. They are both represented in the plate, and only differ from each other in the shape of the brass milled-headed nuts that work upon the screw, of about $2\frac{1}{4}$ inches in length, into which the right-hand end of each hook is formed. Thus, while the nut enters very freely into, and rests upon, the fork, the left-hand end of the hook has a circular hole in it, whereby it slips easily off and on the brass pillar. By referring to the plate, it will appear sufficiently obvious, from the nature of the nut on the left-hand hook, that it could only move the rod on to coincidence, and could not bring it back again, if the business happened at any time to be overdone; in which case it was necessary to move the rod a little backwards by the hand, and then to work anew with the nut, until the coincidence was accurate: whereas the nut on the right-hand hook, having two shoulders, could either push or pull the rod forwards or backwards: and although this appeared to be an advantage, yet it was found from experience, that it rather bound the hook too much, and occasioned a kind of spring in the parts, which sometimes disturbed the coincidence on the removal of the hook; wherefore it

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was often applied, like the other, by placing the screw itself in the fork, and working with both shoulders of the nut behind it.

The positions of the thermometers, and mahogany oval lid on the top of the case, have already been mentioned. This last being unlocked and removed, permits the case to be looked into, or the hand to be admitted, in order to be certain that the fastenings remain safe and entire in the inside. Brass caps, with the respective number of the rods engraved on them, are likewise screwed on the male-screws in the ends of the case, through which the extremities of the tubes project, to preserve them from accidents when not in use. And, lastly, to strengthen the cases, but more particularly to prevent them from being rent, when long exposed to the sun's rays in the field, the sides are covered with brown linen laid on very smoothly, and carefully glued with thin glue, used as a stronger kind of paste, to which it may yet be necessary to add a coat of oil paint.

Each of the glass rods, completed in the manner abovementioned, weighs about sixty-one pounds. Their lengths were ascertained by means of new brass points placed in the great plank, the spaces of forty inches being laid off, with the utmost care, from the brass scale, when the temperature of all had remained for the greater part of two days (August 15th and 16th) at or very near 68°. For this purpose, two brass rectangular cocks, whose alternate surfaces had been previously ground together, were placed upon the plank, so as to bisect the extreme dots; in which situation they presented to each other surfaces that were truly parallel. The rods being then severally placed between the cocks* (or, as was found to be a better method, between the point

* The first of these cocks, or that to which the fixed button was applied, had a hole in it exactly of the height of the centre of the button, and large enough to permit the point of the micrometer screw to pass through it, the said screw being fixed

of a micrometer screw, supplying the place of the first cock, and the second) the ivory intersection was at first necessarily carried beyond the diamond line, so as to make the intermediate space less than it should be, until by the gradual grinding down of the moveable bell-metal button, it was enlarged to twenty feet, as then shewn by the accurate coincidence of the intersection with the diamond line.

It was by these distances in the great plank, prolonged to twenty-five feet, that the new length of the steel chain was now settled, so as to obtain the full one hundred feet at four measurements. At this time too, brass points were introduced into the chain at every twenty-five feet, whereby its extent may be compared on any future occasion; but the temperature had now fallen to $66^{\circ}\frac{1}{2}$.

on the farther side, or beyond the cock. Thus, while the temperature continued accurately at 68°, the fixed button, or any other plane surface, being brought up to the hole in the cock, and the micrometer point screwed so far as just to touch it, the coincidence continuing in the interim perfect, the exact distance of twenty feet was obtained between the point of the screw and the second cock; at which time the division answering to the index on the head of the micrometer was carefully noted. This being done, the cock with the hole was removed from the plank, and the rods were severally adjusted by being placed between the point of the screw and the second cock. This substitution of the micrometer point, instead of the first cock, was found necessary; because, during the operation of adjustment, the temperature would sometimes change a degree, generally in excess, from handling the instruments. One degree of alteration, producing a difference of about $\frac{1}{1000}$th part of an inch in the twenty feet, was very easily and accurately allowed for by such a micrometer as this, which shewed the coincidence of the ivory intersection with the diamond line to be more or less perfect, when the head of the screw was moved two divisions, that is to say, $\frac{2}{10000}$ths or $\frac{1}{5000}$th part of an inch.

Disposition of the Stands for the Double Measurement with the Chain and Glass Rods; Description of the Apparatus then applied to the Ends of the Chain; and ultimate continuation of the Measurement with the Glass Rods alone. Pl. II. and IV.

14. From the various circumstances already mentioned, in the course of this tedious, yet necessary recital, it had been for a considerable space of time foreseen, that the result given by the measurement with the deal rods must be entirely rejected, and that by the glass rods adhered to, as every way deserving of the preference; because of the obvious impropriety there would be, in taking a mean between one indisputably good and another less perfect, however small or trifling in reality the difference of the two might ultimately be found, on a minute and scrupulous comparison.

In order, therefore, to avoid any repetition of the operation with the glass rods, and at the same time to give something like a fair trial to the chain, it was proposed, that a double measurement should be carried on with both at once; that is to say, that the number of stands, and several other parts of the apparatus, should be so far augmented, as to admit the chain to be placed twice in advance, and then the rods to follow in succession on the same stands. Accordingly, the various articles having been sent to the north-west end of the base on the evening of the 17th of August, the operation of the double measurement commenced next morning, the 18th.

By referring to Pl. II. it will be seen, that seventeen stands were necessary for supporting the chain, the apparatus attached to each end of it, and ten coffers, whereof every five made about ninety-eight feet, in order that, one length of the chain being measured off in the first five, it might be drawn forward into the

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last five, and so on. These seventeen stands were disposed of in three groups of three each, and four intermediate, between the central and extreme groups. The middle or slide stand of each group (so distinguished because some of them had brass slides on their tops) supported the handle of the chain, and of course received the traces made at the feather-edged pieces of brass, terminating the beginning and ending of the hundred feet. Thus, there were in all six stands, intermediate to those in the centre of each group that supported the ninety-eight feet of coffering, which was kept so much short of the hundred feet, that its extreme parts might not rest upon, or even touch, the central stands. To that on the left of the centre was attached the apparatus for the first or zero end of the chain; and to that on the right of the centre was attached the apparatus for the last end of the chain. When the second chain length had been measured off, the first and sixth of the coffer stands of the first chain were moved forward to prepare for the third chain; and the four remaining coffer stands were raised, until their surfaces came into the same plane with the slide stands, for the reception of the glass rods. The space by which these stands were raised was about three inches; for so much higher was the surface of the intersole or flooring of the coffers than the stands which supported them.

The apparatus attached to the first end of the chain, or that which served to pull it back to the point of commencement, while a weight continued suspended at the farther end, consists of two parts, as may be seen by referring to the left-hand side of Pl. II. First, a small wooden frame, fitted to slip on to the top of any one of the ordinary stands, placed immediately to the left of that which supports the handle. Secondly, a flat steel rod, about two feet in length, wherein a number of holes are pierced, about an inch asunder, for the reception of a steel pin placed in one of the holes, as best suits the distance of the stand from the handle. That end of

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the steel rod nearest to the end of the chain is formed into a screw about four inches in length, and it receives upon it a forked hook, fitted to lay hold of the straight part of the handle of the chain. Within the forked hook there works a strong mill-headed brass nut, which acting upon the bottom of the fork, the chain is thereby pulled back, until the wire suspending the plummet from the dart on the feather-edge coincides with the point of commencement on the ground underneath; for which purpose there is a hole in the top of the stand through which the wire passes. The apparatus stand, thus serving to pull back the chain, was commonly loaded with double weights, placed on the two hindermost legs.

The apparatus for the last end of the chain consists, like the former, of a small wooden frame, that can be readily slipped upon any of the common stands, as may be seen by referring to the right-hand side of Pl. II. This frame carries a pulley, over which a rope passes, having fourteen pounds weight suspended at one end of it, while a forked iron hook at the other end lays hold of the straight part of the brass handle. By means of these two apparatuses the chain is always kept to the same degree of tension in its coffers, in each of which a thermometer was placed to indicate the temperature; the whole being covered up from the direct rays of the sun by a narrow piece of linen cloth, stretched along it from one end to the other.

Each coffer consisted of three boards about half an inch thick. The sides were about five inches deep, nailed at the middle to an intersole bottom of four inches, in such manner as to be represented in section by the letter H. They were ill made, being by their parallelogram shape apt to warp, which might have been prevented by giving them the figure of the cases of the glass rods, that is to say, making them wide in the middle, and narrow at each end.

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We are now to proceed to give some account of the double measurement with the chain and glass rods; wherein it must be remembered, as also in continuing the operation with the glass rods alone, that in referring to the map for the daily progress in the work, we are going from the forty-sixth towards the first station; and in having recourse to the general table of the base, for altitude, temperature, or correction for expansion, we are ascending from the bottom towards the top, contrarily to the order in which the operation with the deal rods was conducted.

On the morning of the 18th of August, the stands with the various parts of the apparatus being placed in the manner just now described, the operation was begun by bringing the first end of the chain to coincide with the intersection on the tripod, answering to the end of the 1370th deal rod, and 4.31 feet distant from the centre of the pipe terminating the north-west extremity of the base. The chain being stretched along its five coffers by the fourteen pounds weight suspended over the pulley at the farther end, and the temperatures of the five thermometers being registered in a book kept for that purpose, a fine trace was made on a piece of card, fastened under the feather-edge at the farther handle, denoting the end of the first hundred feet. The chain being then moved on into the next five coffers, those that had been thus vacated were carried forward, to prepare for the third chain length, and thereby permit the first set of stands to be elevated for the reception of the glass rods; and so in succession with the others.

In this manner we proceeded, and in the course of the day were only able to measure the length of ten chains, or 1000 feet, being the forty-sixth and forty-fifth hypothenuses of the base, the first of 400 and the last of 600 feet. Being arrived at this point, it was found, that the fine line on the brass slide, marking the extremity

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of the tenth chain, fell short of another fine line on the same slide, denoting the end of the fiftieth glass rod, just two-tenths of an inch. Now it will appear hereafter, when we come to shew, by the experiments with the pyrometer, what the real contractions of the chain and glass rods were, for the degrees of difference of temperature* below that in which their respective lengths were laid off, that this small apparent difference of two-tenths of an inch, between the two modes of measuring the thousand feet, should have been 0.17938 in. to have made the two results exactly agree, which is a real difference of only 0.02062 of an inch. Supposing then every thousand feet of the base to have been measured by the chain with the same attention, and consequently with the same, or nearly the same success (and there surely cannot be any reason to doubt of the practicability), we shall have 27.404×0.02062 in. $= 0.565$ in. or a defect of something more than half an inch on the whole length of the base.

* When the length of the chain was laid off, the heat was $66°\frac{3}{4}$, and that of the glass rods 68°. They will, therefore, only agree with each other accurately in these respective temperatures. The mean of twenty thermometers for the four chain lengths of the forty-sixth hypothenuse gave a heat of 61°.6; and for the six chain lengths of the forty-fifth, the mean of thirty thermometers gave 59°.75. The temperature of the 400 feet of glass, by the mean of forty thermometers, was 65°.3; and of the 600 feet, by the mean of sixty thermometers, it was 60°.8. Now, from these data, and the expansions of steel and glass, as determined by the pyrometer, the computation will stand as follows:

		° °	°	In.	In.	In.	
Steel	400	66.5 − 61.6	= 4.9	× 0.03052	= 0.14955	= 0.45856	contract. of 1000 feet.
	600	66.5 − 59.75	= 6.75	× 0.04578	= 0.30901		
Glass	400	68.0 − 65.3	= 2.7	× 0.02068	= 0.05584	= 0.27918	contract. of 1000 feet.
	600	68.0 − 60.8	= 7.2	× 0.03102	= 0.22334		

The 1000 feet of steel should have contracted more than the 1000 feet of glass, - - - } = 0.17938

But the difference was found to be - - = 0.20000

Therefore the error of the chain in defect was - 0.02062 × 27.404 = 0.565 in. or little more than half an inch on the whole base.

So nice an agreement between two results, with instruments so very different, could not fail to be considered as astonishing; and as it rarely happens, that the graduation of thermometers will so nearly correspond with each other, as not to occasion a much greater error, all were very desirous that it could have been farther confirmed by continuing the operation in the same way through a more considerable proportion of the whole length. But besides the tedious nature of the double measurement, owing to the multiplicity of stands, platforms, coffers, and other articles, that were now successively to be moved forward, and for which purpose it had been found necessary to reinforce the party of soldiers with six additional men; the operation had already trained out to a much more considerable length than had been expected; the summer was now far advanced, and the continuance of good weather uncertain; the coffers likewise for the chain, having been constructed in a hurry, were found to be defective: in short, all these reasons contributed to induce us to give up, for the present, any farther experiment with the chain, and to proceed with the glass rods alone in the completion of the measurement.

Accordingly, on Thursday the 19th of August, the operation with the glass rods was continued for the five hypothenuses, from the forty-fourth to the fortieth inclusive. It will be remembered, that in proceeding with the deal rods, double pickets had been placed in the ground, at the middle of the forty-first hypothenuse, or that point which terminated the 1215th rod, reckoning from the south-east, or the 155th from the north-west end of the base. Now, in returning to this point with the glass rods, the extremity of the 155th fell short of the silk thread stretched from picket to picket, just one-tenth of an inch. The expansion of the brass standard scale, and that of glass being taken into the account, it

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appears, that the small expansion * of the deal rods from the humidity of the air, must, at this point, have exceeded what it was estimated at in the general table by 0.931 of an inch, supposing no error of any kind whatever to have arisen in the execution, from bringing the rods into contact, or otherwise.

On Saturday the 21st of August, the measurement was resumed at the thirty-ninth station, and continued for five hypothenuses to the thirty-fifth inclusive.

This day, about noon, his Majesty deigned to honour the operation by his presence, for the space of two hours, entering very minutely into the mode of conducting it, which met with his gracious approbation.

On Monday the 23d, the mensuration was farther continued for five hypothenuses, that is, to the thirtieth inclusive.

On Tuesday the 24th, we proceeded with the measurement for the space of seven hypothenuses, finishing the business of the day at the twenty-second station.

It will be remembered, that in carrying on the operation with the deal rods, double pickets were left in the ground at the twenty-seventh station, answering to the extremity of the 810th rod from the first, or the 560th from the last end of the base. Now, on arrival at this point, the 560th glass rod overshot the silk thread,

	In.	
* 155 deal rods = 3100 feet	+0.383	for 1° excess of temperature of the brass scale from 62° to 63°.
	+0.651	proportionable part of the estimated expansion from humidity.
	+1.034	equation of the deal rods on 3100 feet.
155 glass rods = 3100 feet	+2.301	for 6° excess of the heat of the brass scale from 62° to 68°.
	−0.436	observed contraction of the glass from the 11th and 12th columns of the table.
	+0.100	by which the 155th rod fell short of the thread.
	+1.965	equation of the glass rods on 3100 feet.
	0.931	Difference of the two equations, under-rated in the expansion of the deal rods.

stretched from one picket to the other, 2.525 inches. Here again we find, that the lengthening * of the deal rods, from the moisture of the atmosphere, differs but little from what it has been estimated at by comparison with the standard, being over-rated only two-tenths of an inch on the 560 rods. In this day's operation, in passing the bridge laid over the old river, the measurement, instead of being made in the hypothenusal, was carried on in the level line, for the space of twenty rods, namely, fifteen rods of the twenty-seventh, and five of the twenty-sixth hypothenuse; which occasions the alteration in the reduction of these two spaces, marked with asterisks in the general table.

As some trouble had been found to attend the crossing of the great road, in the first measurement, owing to the number of carriages that were continually passing, the depth of the ditches, and height of the banks of the old Roman way; therefore tressels, suited for the purpose, had been now prepared: and lest any accident might have happened in conducting this part of the operation, so as to oblige us to a repetition, double pickets were placed in the usual manner in the ground, two rod lengths from the twenty-sixth station, to which we could have referred, without going back as far as the tripod left at the twenty-ninth station, the point from which we had departed in the morning.

Bad weather prevented any progress being made on the 25th;

	In.	
* 560 deal rods= 11200 feet	+1.390	for 1° excess of heat of the brass scale from 62° to 63°.
	+5.258	estimated expansion from moisture.
	+6.648	equation of the 560 deal rods.
560 glass rods= 11200 feet	+8.343	for 6° excess of heat of the brass scale from 62° to 68°.
	+1.821	observed expansion of glass } from columns 11th and 12th.
	−1.191	observed contraction of ditto } from columns 11th and 12th.
	−2.525	over-shot the silk-thread.
	+6.448	equation of 560 glass rods.
	0.200	difference over-rated in the expansion of the 560 deal rods.

and, on the 26th, all that could be done was to measure the twenty-second and twenty-first hypothenuses.

On Friday the 27th, the work went on more expeditiously, having in the course of that day measured six hypothenuses, and placed the tripod at the fourteenth station.

On Saturday the 28th, eight hypothenuses were measured, and the tripod was placed at the sixth station. In this day's operation, being arrived near the bridge laid over Wolsey River, double pickets were placed in the ground in the point answering to the extremity of the 1172d rod, reckoning from the north-west, or the 198th rod from the south-east end of the base, that we might recur to them in case of accident; and the eighteen rod lengths, between this point and the sixth station, were measured on the level, instead of the hypothenusal line, which required the alteration of the reduction, as distinguished by the asterisk in the general table.

On Monday the 30th of August, the measurement with the glass rods was completed; * when the extremity of the 1370th rod overshot the centre of the pipe terminating the base towards the south-east by 17.875 inches, or 1.49 foot. Hence, when the several equations for expansions are respectively taken into the account, we find, that the alteration of the deal rods from the humidity of the air, which, by comparison with the standard, was apparently most considerable in the first and second sections of the base, has now wholly vanished; that is to say, the total amount

* The gentlemen who were present at, and assisting in, the last day's operation, were Captain Bisset, Mr. Greville, Sir William Hamilton, Mr. Lloyd, and Dr. Usher, Professor of Astronomy in the College of Dublin. This last gentleman was so obliging as to observe, with the most scrupulous attention, throughout the whole operation with the glass rods, that the coincidence of the second with the first remained undisturbed, while that of the third with the second was completing.

of it has been over-rated by 20.964 inches;* and this is the contradictory circumstance that has been formerly alluded to.

I have already suggested what appear to me to have been the only three possible causes of this difference, found between the estimated and real expansion of the deal rods; and as we are to abandon that measurement entirely, it is of little or no importance now to endeavour to discover, were it possible, whence it may have arisen. If any error was actually committed, which is the least of all probable, it could only have happened at the place of the tripod, by bringing a wrong point of the stem over it when the operation was resumed. But it is well known, how much care and pains were taken to prevent any thing of that sort. Indeed the hypothenusal distances, as given by the chain, agreed so nearly among themselves, that even a foot or ten inches would have made so remarkable a difference in the situation of the next picket, as could not have passed unobserved. Besides, in returning with the glass rods, after passing the Staines Road, the measurement was gradually found (without any leap whatever) to overshoot the pickets, and at last over-reached the south-east pipe by 17.875 inches. I am therefore inclined to believe, that the difference arises partly from what may have been lost by constantly butting one rod against the other, whereby the end of the 1370th did not reach so near to the north-west pipe as it ought

	In.	
* 1370 deal rods = 27400 ft.	+ 3.389	for 1° of the brass scale from 62° to 63°.
	+ 24.223	estimated expansion from humidity.
	+ 27.612	equation of the 1370 deal rods.
1370 glass rods = 27400 ft.	+ 20.336	for 6° of the brass scale from 62° to 68°.
	+ 5.989	observed expansion of glass } from columns 11th and 12th.
	− 1.802	observed contraction of ditto } from columns 11th and 12th.
	− 17.875	space by which the 1370th rod overshot the pipe.
	+ 6.648	equation of the 1370 glass rods.
	20.964	over-rated in the total expansion of the deal rods.

to, and would have done, if the rods had been applied to each other by coincident lines. It must, however, be confessed, that the near agreement between the glass and deal rods in the upper part of the Heath seems not perfectly reconcileable to this supposition. Nevertheless, the descent being quickest, and the irregularities of the surface much more considerable in the lower than the upper part, might produce some effect in one, which did not take place in the other. But the chief part of the difference I take to have proceeded from over-rated expansion ; that is to say, the rods, when brought into use, contracted sooner than we imagined, and thereby gave a shorter measure than what was assignable to them from the mean of any two or more comparisons.

The last day of August was employed in discharging the party, and removing the various parts of the apparatus to Spring Grove House.

Description of the Microscopic Pyrometer, made use of for determining, by experiment, the Expansion of the Metals concerned in the Measurement of the Base. Pl. V.

15. Having, in the preceding part of this Account, given a very minute detail of the actual operations in the field, that the public, being thus informed of every circumstance, might be the better enabled to judge of the accuracy of the result, it remains yet to point out, in what manner the equations for the expansions of the standard scale, steel chain, and glass rods, applied to the apparent measurement of the base, in several of the preceding notes, have been obtained by means of experiments with the pyrometer.

It is sufficiently well known, that many years ago, a very ingenious and valuable Member of the Royal Society did publish in the Philosophical Transactions (Vol. XLVIII. 1754, No. 79.) an account of experiments made with a pyrometer of his invention.

No doubt was entertained of the accuracy of the experiments here alluded to; on the contrary, they will be confirmed by the account now to be given of these recently made, with which they very nearly agree. But as different pieces of metal of the same kind are certainly susceptible of different degrees of expansion, it was judged best, on the present occasion, to put rods to the test of those very metals that had been made use of in the actual measurement of the base. For, supposing both sets of experiments to have been made with instruments equally perfect, and to have been in other respects equally well conducted, this must always be considered as the most unexceptionable method. Besides, the expansion of rods of the length of five feet being ascertained, the unavoidable error of observations of this delicate nature, becomes lessened in proportion to the excess of their length above shorter rods. In these new experiments too, another sort of pyrometer, invented by Mr. Ramsden, has been applied, of such accurate construction, that it seems not easy to improve it.

The microscopic pyrometer, so named, because by means of two microscopes attached to it, the expansion is measured, consists of a strong deal frame, five feet in length, nearly twenty-eight inches broad, and about forty-two inches in height. The elevation of the eye-piece side, or that which presents itself to the observer, and also of the micrometer end, or that which is towards his right-hand, as well as the general plan of the top, are represented by a scale of one inch to a foot, or one-twelfth part of the real dimensions, in Pl. V. where likewise may be seen the angular view of the fixed end, together with plans, sections, and elevations, of several of the principal parts, done to larger scales. From these, it is hoped, the construction of the machine will be easily understood, without entering into a minute description of the almost numberless smaller parts whereof it is composed.

On the top of the frame, two deal troughs, upwards of five feet

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in length, are firmly screwed. That towards the observer overhangs the frame something more than an inch: that on the farther side is even with the back part. Each of these troughs, which are about three inches square in the inside, contains a cast iron standard prism, whose sides are $1\frac{1}{4}$ inch. The manner in which the prisms are fastened to the bottoms of their respective troughs, and the nature of the apparatuses they carry on their extremities, will be readily conceived, by referring to the particular plans and elevations of them, comprehended in the group of eight small figures towards the right hand of the general plan. Four of these appertain to the left-hand or fixed microscope; and the other four to the right-hand or micrometer microscope, so distinguished, because it has a micrometer attached to it. By means of the brass collars which embrace the prisms, their left-hand or fixed ends are screwed down extremely fast to the brass pieces whereon they rest, so as to be perfectly immoveable there with regard to their troughs; whereas their right-hand ends are kept easy, yet without shake, in their collars, that they may contract or lengthen freely as the temperature may require, without occasioning any strain upon the parts. The prism in the nearest trough may be called the eye-piece prism, because it carries the eye-pieces of the microscopes; and that in the farther trough, the mark prism, because it carries the marks or cross wires at which the microscopes respectively point. The troughs are covered with pitch in the inside, to make them hold water; and each has a cock in the left-hand end for discharging it.

Between the two deal troughs, one of copper, as a boiler, is placed, somewhat shorter than the former, but still upwards of five feet in length. It is about $2\frac{3}{4}$ inches broad, and $3\frac{1}{2}$ in depth. The centre of the boiler, or rather the centre of the object lens which stands in it, as we shall have occasion soon to point out, is distant from the cross wires of the mark 5.81 inches; and

from the wires of the micrometer attached to the corresponding eye-piece 20.33 inches. The boiler rests on five small rollers, one being fixed to each end of the frame, and the other three to the braces which run across it. This copper trough has likewise a cock in the left-hand end; and in the general plan a cast iron prism is represented in it; but this last carries no apparatus, as those in the wooden troughs do, being exactly of the length of five feet, and only placed there as one of the rods whose expansion was tried, and to shew that the machine was capable of receiving a rod of that weight and magnitude.

By referring to the general plan it will be seen, that twelve lamps are made use of to bring the water in the copper to boil. They stand on four shelves, three in each compartment formed by the cross braces of the frame. They can readily be pushed forwards or drawn backwards, and when actually in use, their handles are only seen, projecting from under the copper. It was found, by burning oil in the lamps, the heat of the water could not be raised above 209° or 210°; but with spirits of wine it was brought into violent ebullition. The plan of the frame likewise shews, that the tubes of the microscopes are subdivided into several distinct parts; and that one of these parts is attached by a collar to a mahogany prism, which reaches from one end to the other. But the use of these contrivances it will be best to defer speaking of, till after having described the apparatuses that are placed within the copper boiler.

At the bottom of the plate the boiler is represented, both in plan and longitudinal section, to a scale of one-fourth part of its real dimensions. It contains within it two brass slides, the one long and the other short; which, from the braces that bind the cheeks together, very much resemble the form of a ladder. The long slide, whose cheeks are $1\frac{1}{4}$ inch deep, reaches almost the whole length of the copper, although every where unconnected with it,

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except at the points A and B. At the first of these, two strong pieces of brass, fixed to the cheeks, and notched underneath, embrace the ends of a brass cylindrical bar fastened to the bottom. At the last, the cheeks of the slide rest on a roller. Whence it follows, that the copper and slide remain immoveable with regard to each other at A; but from thence, towards either end, they have full liberty to change place; that is to say, to expand by heat, or contract by cold, in any proportion their different natures may require. The left-hand end of the slide is shut up by a strong perpendicular piece of brass, connected with the two side rings which support the object lens of the fixed microscope, whose centre corresponds accurately with its inward face. This piece being firmly screwed to the cheeks of the slide, and counter-arched outwardly, forms a strong butt for the fixed end of the expanding rod (supposed here to be the steel bar) to act against. Within the right-hand end of the long slide, rests a short one of about $14\frac{1}{2}$ inches in length, whose cheeks are $1\frac{1}{4}$ inch deep. Its outward end, at C, rests on the cylindrical surface of the last brace of the long slide, fitted purposely to receive it; while a narrow longitudinal bar fixed in its inward end, at DE in the section, moves freely in the notch of a bridge F, framed for it in the long slide. The outward end of this short slide is shut up in a similar manner with the opposite end of the long one.

This end piece is also connected with the two side rings which support the tube containing the object lens of the micrometer microscope, whose centre is perpendicularly over its inward face, and being fortified outwardly by an edge bar, it forms a butt for the expanding end of the rod, that is in experiment, to push against. By attending to the plate it will be perceived, that to this end of the boiler a brass tube (R) is fixed, which contains within it a brass rod, surrounded by a helical steel spring; which acting upon

a broad shoulder of the rod prepared for the purpose, thereby presses its inward end, which enters the boiler, against the perpendicular surface of the end piece of the short slide. Thus, the farther end of the rod in experiment, supposed now to be in its contracted state, is constantly made to bear against the surface that is under the fixed microscope. But on the application of heat, the irresistible force of expansion in the rod obliges the spring to give way; the short slide changes its place, and with it the object lens of the micrometer microscope moves on a space proportionable to the degree of heat that is applied; and it is this distance, measured by means of the micrometer, as hereafter will be shewn, that determines the quantity of expansion, or the space by which the rod has lengthened. From the plate it will be further observed, that the rod in experiment rests on the surfaces of three rollers, about an inch in diameter; and by means of three pair of milled-headed nuts, $1\frac{1}{2}$ inch in diameter, which move on axes that are formed into screws, until they almost touch the sides of the rod, this is kept in its true centrical position, whatever may be its form or lateral dimensions.

The microscope towards the left hand has been denominated fixed, because it corresponds with the first or fixed end of the rod in experiment, and never changes its place while these are of the length of five feet. But it appearing to be of consequence, that the expansion of the standard brass scale, which is not quite forty-three inches long, should be determined, the pyrometer has therefore been adapted for the reception of any rods less than five feet, whereby it is made more universally useful. For this purpose it becomes necessary to move the marks and eye-pieces of the fixed microscope, along their respective prisms, to the proper position for the rod that is to be tried. Nevertheless, the object lens remains in its original place; and in its stead another lens, of the

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same focal distance, is fixed on a similar end piece, that can be firmly clamped to any corresponding place whatever of the cheeks of the long slide. Hence will appear the reason for breaking the screening tubes of the microscopes into several parts, and the use of the mahogany prism, along which the thick part of the tube moves from one end to the other.

The pyrometer, since it was first made and tried, has undergone several small alterations, by way of improvements, which it is now unnecessary to describe particularly. One of these was the application of cross levels to the parts of the tube (SS in the general plan) connected with the object glasses. The manner in which they are fixed on will appear from the representations of them in the lowermost left-hand angle of the plate. And the section at the right-hand angle shews the appearance of the double brass hook, universal joint, and milled-headed nut, applied across the middle of the boiler (at TU), whereby the levels are brought to be consistent, when the water is boiling, with the position they had been adjusted to when the temperature was at freezing; that is to say, they are kept parallel to themselves in both states. This was thought necessary, because the application of the boiling water sunk the middle of the slide a small matter, and thereby made the levels run outwards.

The micrometer so often mentioned, being a very essential part of the machine, is represented, both in elevation and horizontal section, to the full size. Its chief parts consist of a micrometer steel screw, which works in the square nut of a brass slide, while the plane part of it enters into a long brass socket, nicely ground to receive it, and thereby preventing all shake. To the square nut, one end of a watch chain is attached; the other end having passed around is fixed to a barrel, which contains a watch spring, coiled up in the usual manner. By this contrivance, any loss of time in the motion of the moveable wire, fixed to the

square slide, is effectually prevented, whether the screw be turned backwards or forwards. The fixed wire, so called because it is only made use of occasionally, appears in the elevation to the left hand of the former, and is farther removed from the observer, being attached to the oval slide which bounds the field of the micrometer. This wire is moved by the insertion of a milled-headed key (although not represented in the plate) fitted to slip upon the square end of its proper screw, which may be seen, in the elevation, projecting above the micrometer head. It has but little motion, being only intended for the measurement of small differences of expansion, or any small space, by leaving it there, while the other wire is repeatedly brought to coincide with, and again depart from it. For particular purposes this wire may be useful; nevertheless, the instrument would have performed very well without it.

The construction of the microscopes will be readily understood, by referring to the figures under that head on the right-hand side of the plate; where the relative situations of the different eye-glasses, with regard to the wires or place of the magnified image, as well as to the eye, are truly represented in their real dimensions; but the distances from these to the object lenses and marks respectively, are contracted or broken off, from want of sufficient room to delineate them otherwise. To increase the angle of vision in microscopes, it is always necessary that they should have at least two eye-glasses, and the fixed microscope in the plate shews them in their usual position, the image from the object lens there being formed between the two, that the dispersion of rays in the first may be corrected by that of the second. But although this construction serves perfectly well every purpose of the fixed microscope, yet it could not answer in the moveable one, to which the micrometer is attached, where equal parts of an image, or their motion, are to be measured by the equable motion of the object

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lens, as shewn by the micrometer: for in that case, the interposition of an eye-glass before the image was formed, would not only have diminished its size, and thereby rendered the measure less accurate; but likewise, by refracting the oblique pencils more than those nearer the centre, it would have destroyed the equality of the scale, and made equal parts of the object itself to have been represented unequally in the magnified image, and consequently erroneously measured by unequal parts of the micrometer. It was to remedy a defect of this sort that Mr. Ramsden proposed this new system of eye-glasses, described in the Philosophical Transactions, Vol. LXXIII. 1783, No. 5. And he has here applied that system in the construction of the micrometer microscope; where it will be perceived, that both glasses stand between the eye and the image, whereby the greater magnitude of this last is obviously preserved, as well as the just similarity of all its parts to those of the object itself.

With regard to the scale of the pyrometer, it is, in the first place, to be observed, that the head of the micrometer screw, which is nine-tenths of an inch in diameter, is divided into fifty equal parts, each of which being reckoned two, it is therefore numbered to 100. Fifty-five revolutions of the head, being equal to 0.77175 of an inch, as measured with great accuracy by Mr. Ramsden's straight-line engine, it follows, that there are 71.27 threads of the screw in an inch; that seven revolutions and nearly $\frac{13}{100}$th parts move the wire of the micrometer one-tenth of an inch; and that $\frac{1}{100}$th part of a revolution, or half a division, answers to a motion of something more than 0.00014 of an inch.

Having thus obtained the number of revolutions and parts of the micrometer (7.13) corresponding to one-tenth of an inch at the wires, it is sufficiently obvious, that the number answering to

one-tenth LM at the mark being likewise obtained, and added to the former, their sum will give the measure of one-tenth at the object lens, or the space by which the expanding rod has lengthened, as shewn by the motion of the lens from *o* to *p*. This measure of one-tenth of an inch at the mark, was ascertained in two different ways, and the results exactly agreed with each other. In the first place, a very thin ivory slide, whereon several twentieths of an inch were nicely divided by exceeding fine lines, was prepared, and made to move in the mark where the brass slide now exists. A candle being then placed behind it at night, while the pyrometer stood within doors, and the micrometer wire being repeatedly moved by the screw, its coincidence with the lines was distinctly seen through the ivory; whereby two of the spaces were found to be measured by 24.93 revolutions of the head. The second method was, by means of two exceeding fine wires placed parallel to each other on the brass slide, where they now remain, at the distance of one-twentieth of an inch on each side of the intersection wires, as may be seen by observing the real mark, or rather its magnified image, as shewn in the oval field of the micrometer, in the central figure of construction. The revolutions of the micrometer answering to the distance between these parallel wires was, as before, found to be 24.93; which being added to 7.13, we have 32.06 for the number of revolutions measuring a motion of one-tenth at the object lens, or the expansion of one-tenth. In this manner Mr. Ramsden obtains the scale of his pyrometer, in the easiest and most simple way imaginable, without any necessity for knowing the absolute distances of the object lens from the wires of the mark on one hand, and those of the micrometer on the other; distances not easily ascertained by actual measurement, on account of the position of that glass in its cell, which cannot conveniently be come at. Thus, in Pl. V. as well

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as in the annexed figure, LM being the object at the distance of the mark, equal to one-tenth of an inch; then ml will be its magnified image, in proportion to the former as mo is to oM. And if, through the point p, the place to which the object lens o has been carried by the motion of the expanding rod, a line Mq be drawn parallel to Ll, we shall have $ml = 24.93 + lq = 7.13 = mq = 32.06$, the number of revolutions of the micrometer measuring op, the expansion. Having thus obtained the total number of revolutions corresponding to mq; and having likewise measured the total distance mM$=26.144$ inches, a space easily ascertained between the wires of the micrometer and those of the mark, the partial distances mo and oM may then be readily found by computation: for $mq : ml :: m\text{M} : mo = 20.33$ inches; and $mq : m\text{M} :: op : o\text{M} = 5.814$ inches.

In order to finish the description of the pyrometer, it is only necessary to observe farther, that the circular scale, seen in the elevation of the micrometer, whose zero appears to coincide with the dart on the plane part of the brass, is that which serves by its motion to register the turns of the head. A forked key, fitted to enter the holes near the circumference of the circle, is made use of for the adjustment of this zero. The circle should never be turned backwards, or towards the left, lest the watch chain should thereby be thrown off the barrel, but always forwards, or towards the right, even if it should be necessary to move it almost an entire revolution. The zero of the head is that which should be first brought to correspond with its proper dart. They may be seen to coincide in the horizontal section of the micrometer; and the departure of zero from this dart, indicates,

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by the number of divisions that are intercepted, the value of any fractional part of a revolution.

Account of the Experiments with the Pyrometer.

16. Although the instrument which I have here endeavoured to describe was begun early in the winter of 1784, yet it was not finished till the beginning of last April; at which time it was brought to Argyll-street, and being placed truly level on the stone pavement of the yard, was covered with an oil-cloth canopy, that the experiments might not be interrupted by rainy weather.

To fill the three troughs completely, it required from twenty-five to thirty pounds of pounded ice, which was always put in with great care, so as to apply as compactly as possible to the standard prisms and rod respectively, with but little common water* at first added; it having been found in these experiments, that ice water only, such as drains from the ice itself, is that which should properly be made use of to mix with the pounded ice, in order to bring the whole mass to the true freezing temperature. Being at the commencement uncertain what time might be necessary for the rods, especially when of so large a size as the standard prisms, to acquire the just temperature of freezing; at first the ice was put into the troughs over-night, to prepare for the continuation of the experiment next morning. But after many repeated trials, this precaution was found to be needless; a quarter of an hour being more than sufficient to give to all the freezing temperature, as well as to render the lens on

* When common water was used, although not in any very considerable proportion, the thermometer kept always half, and sometimes three quarters of a degree above 32°.

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the expanding rod stationary, after the water supplying the place of the ice had been brought fairly to boil.

The instrument, in its first state, having in some cases made the expansion appear to be progressive, and not equable; therefore its rate was attempted to be ascertained, by noting the progression answering to 60°, 120°, and 180° above freezing. But when the instrument was rendered perfect, and that no sensible difference was found between the expansion at the lower and that at the upper part of the scale, a fair mean being taken between its ascending and descending rates, and allowing for the difficulty of keeping the water, for any length of time, precisely to the same intermediate heat: then this tedious mode of conducting the experiments was given up, and the expansion for 180° was at once determined by bringing the water to boil around that rod, which but a little before had been lying in melting ice, and which the standard prisms still continued to do throughout each experiment, care being taken to have a supply of pounded ice always ready, to keep these two troughs quite full.

Two observers are necessary for the effectual application of the pyrometer. He who observes with the fixed microscope, takes care that its object lens is kept in its true place; that is to say, that the wire in the eye-piece accurately bisects the intersection wires of the mark. This he is enabled to do by means of the apparatus attached to the fixed end of the boiler, as will be best conceived by observing the plan (at WX) along with the elevation of that end placed near it. The apparatus consists of two milled-headed screws, working in brass plates fastened to the end of the frame, and acting against a small cock which projects from the lower part of the boiler, whereby this last receives such longitudinal motion to and fro on its rollers, as is sufficient for the adjustment of the lens. He who observes with the micrometer microscope, having brought the zero of the micrometer head to its

dart, as shewn in the horizontal section, and also the revolution zero to its dart, as represented in the elevation, takes care, when the rod has acquired the freezing temperature, that the micrometer wire bisects the intersection wires of its proper mark. This he effects by working with the milled-headed screw, represented in the plan and elevation of that mark, whereby the mark itself is moved until the bisection is accurate; and during the whole of this time, the first observer must be extremely attentive to keep his lens adjusted.

One assistant at least is necessary, who takes his station on the opposite side of the pyrometer, to observe the levels, and keep them adjusted, by means of the double hook applied near the middle of the boiler, and represented in the section on the line TU, at the lowermost right-hand angle of the plate.

The pyrometer having been adjusted in the manner here described, by giving sufficient time for the standard prisms and rod to contract to the true freezing temperature, as was easily known by the wires becoming perfectly fixed and stationary with regard to the marks; the ice was then removed from the copper trough: and the same being filled with water nearly on the boil, the ebullition was completed, and kept up, by means of the lamps now lighted for the purpose, and slipped in underneath.

The expansion, answering to the 180° between freezing and boiling, was now measured by working with the micrometer screw until the bisection* of its wire with those of the mark was again complete; the observer at the fixed microscope taking also especial care all the while to keep his bisection perfectly accurate.

* This bisection of the wires may always be made to a great degree of precision, by one with a tolerably good eye, and accustomed to observations of this sort. I have myself repeatedly adjusted the wires eight or ten times running, allowing another person to read off and unadjust each time, without the mean difference exceeding one-fourth of a division of the head, which is only $\frac{1}{32000}$th part of an inch.

The number of revolutions, registered by the number of entire divisions that the zero of the circular scale had departed from its dart or index, and also the value of any fractional revolution, registered by the divisions on the head intercepted between zero and its proper dart, were then noted, as expressed in the first column of the subjoined table of experiments; which requires no other explanation than what is therein inserted, and which has been extended purposely to shew at one view, from inspection only, how much the length of our base would have been affected, if measured by these metals respectively, in temperatures between 32° and 62°.

All the experiments were repeated at least twice, and some of them three times, except the standard scale and glass pendulum rod, whose expansions were only tried once. The difference of a few divisions between the mean and extremes on the heat of 180°, being, in things of this sort, of no importance, it was judged wholly unnecessary to aim at a greater degree of precision in repeating them oftener. By referring to the table, particularly that column containing the expansions on one foot by 180°, it will be perceived, that they are uniformly a small matter less than what has been assigned to the same metals respectively, in the experiments formerly alluded to.

Ultimate Determination of the Length of the Base on Hounslow Heath.

17. In the former part of this Account, we have had occasion to speak of the seven first columns of the General Table of the base; and the titles at the tops of the others respectively serve sufficiently to explain those towards the right hand; the expansion of glass above, and its contraction below 62° contained in the

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eleventh and twelfth columns, being deduced from the recent experiments with the pyrometer.

	Feet.
The hypothenusal length of the base, as measured by 1369 925521 glass rods of twenty feet each + 4 31 feet, being the distance between the last rod and the centre of the north-west pipe, is found to be - - - -	27402.8204
The reduction contained in the seventh column of the general table to be deducted is - -	0.0714
Hence the apparent length of the base, reduced to the level of the south-east extremity, becomes	27402.7490
The apparent length is to be augmented by the excess of the expansion above the contraction of the glass rods, contained in the thirteenth column of the general table=4.1867 inches, reduced to the heat of 62°, as has been usually done in former operations of this nature - - - -	0.3489
The apparent length is farther to be augmented by the equation for 6° difference of temperature of the standard brass scale and the glass rods, between 62° and 68°, this last being the heat in which the lengths of the glass rods were laid off =11,8368 inches, * as deduced from the experiments with the pyrometer -	0.9864
Hence we have the correct length of the base in the temperature of 62° reduced to the level of the lowermost extremity near Hampton Poorhouse, -	27404.0843

* Expansion for 6° on the whole base $\begin{cases} \text{brass standard} = 3.38938\ \text{In.} \times 6 = 20.33628\ \text{In.} \\ \text{glass rods} = 1.41658 \times 6 = 8.49948 \end{cases}$

diff. 11.8368 = 0,9864 feet.

	Feet.
This last length requires yet a small reduction for the height of this lowermost end above the mean level of the sea, supposed to be fifty-four feet, or nine fathoms, - - - -	0.0706
Hence the true or ultimate length of the base, reduced to the level of the sea, and making a portion of the mean circumference of the earth, becomes -	27404.0137

As some small degree of uncertainty remains with regard to this last reduction, it may not be improper to say yet a few words on the principles that have been adhered to in making the computation. It will be remembered, that the measurement was made $3\frac{1}{2}$ feet above the surface of the Heath, that being the height of the stands whereon the rods were placed; and that the telescopic spirit level gave a descent of 36.1 feet from the lowermost pipe to the surface of summer water in the Thames at Hampton. The accurate section of the river lately published, gives a fall of 13.33 feet from Hampton to the level of low-water spring tides at Isleworth. Now these three being added together, we have nearly fifty-three feet for the height of the base above Isleworth. Having had no immediate means of determining what real difference there may be between Isleworth and low-water spring tides at the mouth of the Thames (for instance at the Hope or the Nore), I have supposed that fall to be about seven feet, so as to make the total descent sixty feet. Now, supposing the spring tides at the Nore to rise eighteen feet, if, according to M. De la Lande's method, we deduct one-third of eighteen, viz. six feet from sixty, we shall have fifty-four feet, or nine fathoms, that the mean surface of the sea is below the measured base. Whether this conclusion be perfectly accurate or not is of no moment, since a whole fathom of difference (and I apprehend we are not farther from the truth)

does not vary the reduction quite one-tenth of an inch. The reduced base has therefore been found by the following analogy: as the mean semi-diameter of the earth (supposed here to be 3492915 fathoms) augmented by nine fathoms, is to the mean semidiameter, so is the measured base 27404.0843 to the reduced base 27404.0137 at the level of the sea.

It will doubtless be allowed, that infinite pains have been taken in the field and otherwise throughout the whole of this operation, to obtain a just conclusion.

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Third or north-west section, between the side of the Staines Road, and King's A near the Colnbrook Road.	30	- -	0.165	19.715	- -	0.0
	31	0.14	- -	19.855	- -	0.0
	32	- -	0.12	19.735	- -	0.0
	33	- -	0.14	19.595	- -	0.0
	34	1.21	- -	20.805	- -	0.0
	35	1.405	- -	22.21	- -	0.0
	36	2.34	- -	24.55	- -	0.0
	37	- -	1.085	23.465	- -	0.0
	38	0.47	- -	23.935	- -	0.0
	39	0.525	- -	24.46	- -	0.0
	40	1.265	- -	25.725	- -	0.0
	41	1.18	- -	26.905	- -	0.0
	42	- -	0.19	26.715	- -	0.0
	43	1.565	- -	28.28	- -	0.0
	44	1.485	- -	29.765	- -	0.0
	45	0.24	- -	30.005	- -	0.0
	46	1.26	- -	31.265	12.130	0.0
	400 ft.					
		40.44	9.175	31.265	31.265	0.0

Hypothenusal length of the base containing 1369.9255
Reduction contained in the seventh column to be subt

Total apparent length of the base reduced to the level
Add to the apparent length the difference between tl
62°, contained in the thirteenth column = 4.1867 i
Add further to the apparent length, the equation for
glass rods, between 62° and 68°, the heat in which t

Correct length of the base in the temperature of 62°, r
Reduction for the height of the lower end of the base
9 fathoms - -

True length of the base reduced to the mean level of t

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: Pyrometer in April, 1785.

Description of		expansion is			Bases of 27400 feet of these metals would expand.			
		oo feet.	600 feet.	1000 ft.	By 1°.	By 10°.	By 20°.	By 30°.
		In.	In.	In.	In.	In.	In.	In.
Standard brass scale.	Supp 42.187 thickne expansi the mic have be	.04948	0.07422	0.1237	3.38938	33.8931	67.7876	101.6814
English plate brass, in form of a rod.	Leng 0.15 in. its thin.	.05048	0.07572	0.1262	3.45788	34.5788	69.1576	103.7364
English plate brass, in form of a trough.	Leng inch; straight	.05052	0.07578	0.1263	3.46062	34.6062	69.2124	103.8168
Steel rod.	Leng 0.3 inc very sar	.03052	0.04578	0.0763	2.09062	20.9062	41.8124	62.7186
Cast-iron prism.	Leng weight the stan	.02960	0.04440	0.0740	2.02760	20.2760	40.5520	60.8280
Glass tube.	Leng 1 lb. 1 with th	.02068	0.03102	0.0517	1.41658	14.1658	28.3316	42.4974
Solid glass rod.	Leng meter si It had Its exp of the would h	.02156	0.03234	0.0539	1.47686	14.7686	29.5372	44.3058

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An Account of the Trigonometrical Operation, whereby the Distance between the Meridians of the Royal Observatories of Greenwich and Paris has been determined. By Major-General William Roy, F. R. S. and A. S.

Introduction.

18. THE trigonometrical operation which becomes the subject of this work, had its commencement, as will be remembered, in the measurement of a base on Hounslow Heath in 1784. an account of which was given to the Royal Society in the following year.

In the spring of 1787, Sir Joseph Banks opened (through the official intercourse of his Majesty's secretary of state, the Marquis of Carmarthen, with the ambassador at the court of France) a correspondence with the Academy of Sciences, regarding the co-operation expected on their part, for connecting the triangles which we were now preparing to extend along the English coast, with those formerly executed on the coast of France, opposite to Dover. And Dr. Blagden had engaged to assist in the business, on the appointment of the Royal Society, whenever we should be enabled to assign any probable time, for the different parties to repair to their respective coasts, for the aforesaid co-operation.

About the same time likewise, a paper was laid before the Royal Society, intended as a sketch of the mode proposed to be followed in carrying the scheme into execution; for which purpose it was accompanied with a general map, shewing nearly the disposition of the triangles.

For several months of the spring and summer of 1787, Mr. Ramsden had been seriously at work, in endeavouring to finish the

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instrument intended for the measurement of the angles. Not having employed a sufficient number of workmen upon it at the outset, it was now evident, that he had even deceived himself, by leaving too much to be done at the latter end. At length, however, the instrument was produced, and placed, on the 31st of July, at the station near Hampton Poorhouse.

By commencing an operation of this nature, at so advanced a season of the year, it was sufficiently obvious, that only very faint hopes could be entertained of bringing it to a conclusion before the bad weather would set in. But it being of much importance to get the triangles, which extend across the Channel, at all events executed, it was therefore proposed to Comte de Cassini, who by this time had been appointed by the Academy of Sciences, to superintend their part of the business, that he should fix the time that might suit him best for our meeting on the coast; that we would then discontinue the operation to the westward, and, having in concert executed the coast triangles, we would resume the inland parts of our own series at some more convenient opportunity.

This proposition being readily acceded to by Comte de Cassini, the 20th of September was appointed for our repairing to the coasts of Dover and Calais respectively.

In the mean time our operation was continued, with all imaginable care and assiduity, through the first ten stations of the series of triangles, from Hampton Poorhouse to that at Wrotham Hill inclusively.

The instrument, and the various parts of the apparatus, were then removed to Dover, at which place Mess. de Cassini, Mechain, and Le Gendre, three distinguished members of the Academy of Sciences, arrived on the 23d of September.

In the course of two days that these gentlemen honoured us with their company at Dover, every thing was settled in the most amicable manner possible, with regard to the times of reciprocal observation.

A great number of white lights, fitted for long distances, and several reverberatory lamps had been previously provided. Having been supplied with such a proportion of the lights as seemed necessary for their side of the Channel, and one of the lamps, the French gentlemen departed for Calais on the 25th, accompanied by Dr. Blagden, who attended them during the time of the cooperation, until it was finally closed on the 17th of October.

For the greater part of the time, the weather was extremely bad; nevertheless, on the particular nights when the most important observations on our side were made, namely, those at Dover and Fairlight Down, the nights happened very fortunately to be favourable, so as to enable us to intersect, with great accuracy, the two distant points on the French coast of *Blancnez* and *Montlambert,** and thereby to establish for ever, the triangular connection between the two countries.

The Duke of Richmond, Master General of his Majesty's Ordnance, had, in the most liberal manner possible, given every assistance to the operation (from that great department over which he presides with so much honour to himself and advantage to the public) by furnishing an officer and a detachment of artillery-men for the work; ordering the laboratory at Woolwich † to supply whatever fire-works might be wanted for signals; and temporary scaffolds to be erected at Greenwich Observatory, Shooter's Hill, and Dover Castle, for the reception of the instrument. But what was still of more importance than any of these, his Grace had permitted Lieut. Fiddes (one of the engineers, on the survey then under my direction) to be employed, in the summers of 1786 and 1787, in making a very accurate plan of that part of Romney Marsh where the base of verification was to be measured. In a country so much

* The name of this hill is vulgarly pronounced *Boulemberg*, and it is even written in the same manner in the book, *La Méridienne vérifiée*.

† Major Congreve, of the Royal Artillery, had the management of the lights at Shooter's Hill; and his assistance was found to be most essentially useful.

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intersected by ditches, and where there were so many ponds of water to be avoided, without such a plan raised beforehand; an operation of so delicate and difficult a nature could not have been effected.

The apparatus for the measurement of the base with the steel chain, notwithstanding the urgency of the case, was not sent to its destination until the end of the first week of October. To Lieut. Fiddes the engineer, was then joined Lieut. Bryce of the Royal Artillery; and it was not before the beginning of December, that these two gentlemen, with the most unremitting labour and perseverance, were able to accomplish the measurement, as will be seen hereafter in the detailed account of that operation.

In finishing the co-operation with the French Commissioners, at Lydd on the 17th of October, our instrument had now passed through sixteen stations out of twenty-three. There of course remained yet seven stations where it was to be placed, and observations to be made. Eagerly wishing to bring the business to a conclusion, we struggled on through five of the seven. But the weather at length became so tempestuous, that it was utterly impossible to continue it, with any hopes of being able to make satisfactory observations. Perched on the tops of high steeples, such as Lydd and Tenterden, or on heights, such as Hollingborn Hill, we sufficiently experienced, that operations of this sort, where the most important observations could only be made at night, by means of the white lights, should never be undertaken in the latter season.

On the second of November, the instrument was accordingly removed from the top of Hollingborn Hill, and sent to town, leaving the stations on Goudhurst and Frant Churches, both likewise situated on eminences, unoccupied until the ensuing season.

The winter months were employed in calculating the observations that had been made; and from these we were very well enabled to judge to what a degree of accuracy we had arrived in

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determining the sides and angles: for Frant and Goudhurst, having been intersected from Botley Hill, Wrotham Hill, and Hollingborn Hill; Goudhurst having been observed from Tenterden, and Frant having (contrary to our expectation) been seen and observed from Fairlight Down, we had thereby the certain means of determining very nearly what difference there would be between the measured and computed length of either base as given by the other, although observations had not been made at the two intermediate stations of Goudhurst and Frant. This difference, it was seen, would be but trifling. In as far, therefore, as the results of the plane triangles were concerned, we might have proceeded with the computations, and drawn the consequent conclusions, without hesitation, or any risk of sensible error.

But, besides that it might still have been said that the instrument had not been placed at these two stations, there were reasons of a different kind, which rendered it in some degree necessary to place the instrument not only at Goudhurst and Frant, but also at Botley Hill and Folkstone Turnpike, where it had formerly stood.

We made observations of the pole-star at Dover Castle, but that station, though about 466 feet above the sea, is nevertheless surrounded on the land side with eminences, at the distance of six, or seven miles, still higher than itself. From that circumstance, we found it impossible to connect it with the triangles to the westward, otherwise than by a short side: and consequently the observations of the star became useless. Botley Hill, Goudhurst, and Folkstone Turnpike, therefore, presented themselves as eligible stations for observing the directions of the meridian.

In 1787, when at the station on St. Ann's Hill, in a very high wind, the box containing the axis-level was blown from the scaffold, and unluckily broken. Another sort of clamp: also an eye-piece, with a diagonal prism, for more conveniently observing the pole-star (or other high object), were necessary improvements. Those,

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however, with a new axis-level, were not ready till the beginning of August, 1788.

The observations at Goudhurst, Frant, Botley Hill, and Folkstone Turnpike, having been finished early in September, the instrument was brought back to town, in the neighbourhood of which it was employed for three days for the following purpose.

In 1787, when at the stations of Hundred Acres, Norwood, Greenwich, and Shooter's Hill, we had only been able to determine, in a satisfactory manner, two points within the limits of the Capital, namely, St. Paul's Church and Argyll-street, the last by means of the white lights. Bearings of some others, it is true, were obtained; but, in order that these might be intersected in the best manner, it became necessary to place the instrument at one or more stations to the northward of the town.

With the view, therefore, of laying the foundation hereafter for a much more accurate plan of London than could possibly be obtained in any other way, the instrument was placed, first, at Hornsey Hill, to the eastward of Highgate; and secondly, on Primrose Hill, between London and Hampstead.

Although the weather was rather unfavourable at the time of making the observations from these two new stations; and that the smoke constantly hanging over the town in the latter season impeded us greatly: nevertheless, the former bearings were intersected, and the situations of a considerable number of remarkable steeples within London and its environs, were accurately determined, as will more fully appear in treating of the secondary triangles.

Having thus briefly shewn the order, with regard to time, in which the recent operation, through its various steps, was progressively carried on and completed, it is proper that I should mention, that Mr. Dalby, who had been recommended as an assistant, has acquitted himself throughout the whole perfectly to my satisfaction.

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Description of the Apparatus made use of in the Measurement of the Base of Verification in Romney Marsh, with the hundred-feet steel chain, in the autumn of 1787, with the result of that operation. Reference to be had to Plates VI. *and* VII.

Preamble.

19. In the account of the measurement of the base on Hounslow Heath in 1784, we had occasion to show, how very accurately distances might be determined by the steel chain, when applied in the ordinary way on the natural surface of the ground, if that surface happened to be tolerably smooth, which was the case in the instance alluded to. By the comparison of the measurement of a length of one thousand feet with the glass rods, and with the chain when used with an apparatus adapted to the purpose, it further appeared, that the difference between the results was so very small as scarcely to be discernible, since it would not have exceeded half an inch on the whole length of that base of 27404 feet.

Having always considered the experiment on Hounslow Heath, just now mentioned, as positive proof of the excellency of the chain, it had been resolved on to apply it to the mensuration of the base of verification in Romney Marsh, even if no other reasons had existed to make that choice eligible. But besides the danger of having the glass rods broken, in transporting to so great a distance from London, and, on such an event happening, the impossibility of getting them replaced with others, at the advanced season of the year in which we were unfortunately thrown with the operation, it was obvious, that in a plain of the breadth of six miles, so much intersected with ditches full of water as Romney Marsh in reality is, the laying of bridges for the tripod stands,

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which must have been used with the glass rods, would alone have been a very troublesome and tedious operation.

Beech Posts.

20. In the first place, about thirty posts made of beech wood, three inches in diameter, and of different lengths, from two feet three inches to three feet six, and a few of them still longer, were provided. They were shod with iron, and each of them carried on its top a cast-iron ferrule, with two dovetails projecting from it; care being taken in driving them into the ground, that the dovetails should stand in or nearly in the direction of the base, as represented by the plan and section of a single post in the middle part of Plate VI. The arrangement of twenty-four of these posts may be seen at the top of the said plate, for the measurement of a portion of the base equal to one hundred yards, or the length of three chains. Sixteen of the posts, reckoning from that which stands in the centre of the first group, to that which stands in the centre of the second, and so on from right to left, were placed at the distance of twenty feet from each other. The first is supposed to coincide with the mouth of the pipe sunk into the earth, at the eastern extremity of the base, at a place called High Nook near Dymchurch; and every fifth post from that towards the left, marks the end of a chain. The other eight posts in the arrangement, that is to say, the right and left posts of each of the four groups, are supposed to stand twelve or fifteen inches from those in the centre. By referring to the elevation near the top, and the plans and section in the middle part of Plate VI. it will be perceived, that these posts, together with certain other iron parts of the apparatus fixed to them, hereafter to be described, support the ends of the coffering for each chain, free and independently of the central posts, to which last the brass scales alone are attached.

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Deal Coffers.

21. Fifteen deal coffers, numbered from one to fifteen, were necessary for the length of three chains, being five to each. Six of them, that is to say, the first and fifth, the sixth and tenth, the eleventh and fifteenth, being the first and last of each chain, were only nineteen feet four or five inches in length. The other nine, being the three in the middle of each chain, were of the complete length of twenty feet. These coffers perfectly resembled in shape, and nearly in dimensions, the cases of the glass rods, being ten inches broad in the middle, and uniformly of that depth throughout their whole length. But from the middle they became gradually narrower, in a curvilinear manner, towards each end, where they were only two inches wide. The two cheeks or sides were about half an inch thick, and the bottom, which entered into a shallow groove in the middle of the cheeks, was an inch in thickness. Thus the cheeks being thin, bent and applied easily to the bottom, to which they were firmly nailed, and the whole was fortified by small blocks of wood fastened at intervals in the inside, sometimes above and sometimes below the bottom. From the elevation it will be perceived, that nine or ten inches of the under extremities of the cheeks were cut off, so as to permit the bottom itself to rest on the irons. This construction of the coffers was found to answer very well, that is to say, they were, considering their length, not so heavy as to be unmanageable, at the same time that by their general figure, and particularly the depth of the cheeks, they were entirely prevented from warping.

In addition to the fifteen coffers, just now described, a sixteenth, not represented in the plate, was afterwards prepared at Hythe, by Lieut. Fiddes, to be used occasionally, when the end of one chain, and commencement of another, coincided with a deep ditch or one of the sewers full of water, and where of course it would have been

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extremely difficult, if not impossible, to have fixed steadily the group of three posts in the usual manner. In this coffer there was a double or false bottom, with grooves adapted for the purpose; and the brass scale, pulley, &c. were removed from the irons, and placed on this bottom.

Apparatus of cast iron, &c. for the Ends of the Chain.

22. By referring to the plate, where the several parts of the apparatus for the extremities of the chain are represented in plan and section, by a scale equal to one-fourth of their real dimensions, it will appear that the cast-iron pieces were of two different forms, one long, and the other short; but both applied in the same manner, on the ferrules binding the tops of the posts, as has been already mentioned. Of the long kind there were in all fifteen or sixteen, that is to say, one for each post in a length of three chains. Each iron had two clamps on its under side, which being slackened, it was placed on its ferrule at right angles to the line of measurement; and being turned round 90°, the dovetails of the ferrule, standing originally in the direction of the base, came within the clamps, which were then tightened by four screws, turned with square keys adapted to the purpose.

It is sufficiently obvious, that so many irons, with such a number of screws to each, could not fail of rendering this operation tedious! The business would have been greatly expedited if there had been only two such screws, one on each end, in a middle situation; and, instead of the four screws, there should have been four steady pins, entering easily into holes prepared for them in the under side. A short groove, of two or three inches in length, in each extremity of the bottom, would, on this supposition, have been necessary to suffer the square heads of the screws to pass; and it will be readily conceived, that the thickness of the

bottom would have effectually secured the chain from touching them, prevented the mutilation of its handles, and saved much loss of time. Indeed the same purpose might have been effected, but not so advantageously, by laying the original four screws lower in the iron, which its thickness easily admitted of. Finally, in order to avoid such like inconveniences in future, there is still one imperfection more, which it is incumbent on me to remark, namely, that cast-iron ferrules will not answer; for the force that was found to be necessary to drive the posts into the ground, burst almost the whole of them, so that before the operation was completed, they were obliged to be replaced with others made of hammered iron, forged for the purpose.

Of the short irons, only three were necessary, one for each end of the chain, and a spare one in case of accident. They were placed, turned, and clamped on the ferrules, in all respects similarly with those of the long kind. By inspection of the plate it will be seen, that each of them carried on its surface a brass scale of six inches in length, divided into inches and quarters, and moveable in a slide, either backwards or forwards, by a finger-screw adapted to the right-hand end.

The right-hand post of each group is called the *drawing-post*, because the iron fixed on its top carries a small apparatus of brass, which being connected with the flat iron rod and hooks formerly used at Hounslow Heath, for a like purpose, lays hold of the rear handle of the chain, and draws it back until zero coincides with the point of commencement. The left-hand post in each group is called the *weight-post*, because it carried a brass pulley, over which a weight of 28 *lbs.* was hung by a small rope attached to the hooks that laid hold of the front handle of the chain. This weight acting against the force of the screw at the other end, the chain was thereby kept perfectly straight in the coffers, and constantly in the same degree of tension, until some certain division

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(the nearest for instance) of the scale could be brought, by means of the screw, accurately to coincide with 100 feet at the front end. That division, whatever it might be, was of course registered in the field book of the operation, together with the true temperature of the chain, as shewn by five thermometers, one being laid for that purpose in each coffer, and secured with white cloth from the sun's rays, as occasion might require.

Fifteen coffers were always arranged on the ground at the same time, comprehending a space of the base equal to the length of three chains, or 100 yards. The extremities of the first chain having been accurately transferred, in the manner above mentioned, to the brass scales on the tops of the central posts, and these remaining firm and motionless, as being wholly unconnected with any other parts of the apparatus, the chain was then moved forward into the second set of coffers, where the thermometers were also placed. In the mean time, the first set of coffers, now vacated, with their posts, &c. were carried on and arranged in the front, for the measurement of the second 100 feet: and so on continually with the others in succession.

Of the Survey of Romney Marsh previously to the Measurement of the Base.

23. In the introduction to this Account, it has been mentioned that the Duke of Richmond had permitted Lieutenant Fiddes, of the Royal Engineers, to be employed in 1786 and 1787 in raising a plan of that part of the Marsh where, on examination, it should be found, that the base of verification might be the best executed. In justice to that Officer, I consider it as incumbent on me to say, that it was impossible for any person to fulfil the duties entrusted to him better than he did, either in the course of the survey, or subsequent measurement of the base, whereof he also had the

direction. The general instructions given to him were, that after having, by a base of his own, determined certain triangles in the neighbourhood of Dymchurch, Ruckinge, and Romney, by way of foundation for his work, he should preserve Ruckinge as the point whereon the *alignement* of the great base was to be directed, and vary the position of that end next the sea-wall in such a manner as to meet with the fewest local obstructions to the measurement between the two extremities. By inspection of the plan, Plate VII. which comprehends a tract of country of two miles in breadth, one on each side of the base line, it will be perceived, that besides the numberless ditches with which this singular plain is intersected, and which it was impossible to avoid crossing, there is almost in every field a watering pond for the cattle, many of them of considerable depth. Nevertheless, so very attentive had Mr. Fiddes been to the accuracy of his survey, that he was enabled, after several trials of other directions, to run a line from High Nook on Dymchurch Sea-wall, upon the small spire of Ruckinge Church, of the length of nearly six miles, without interfering with any one of the watering ponds, or meeting with any other local obstruction of consequence. So very minute was he in his remarks, and so accurate in the situation of particular trees, that in tracing his line with the telescope, he managed so as to avoid them all, a few insignificant bushes excepted; which I believe to be an instance of exactness scarcely to be equalled.

Pipes sunk in the Ground.

24. Permission having previously been obtained from the proprietors of the soil, pipes were sunk into the ground at the two extremities of the base, and also one on Allington Knoll, which last point with Lydd Church* form that side of one of the great

* Mr. Cobb, of Lydd, an ingenious gentleman, well acquainted with Romney Marsh, was so obliging as to present me with a manuscript map of that singular

triangles depending on the base on Hounslow Heath, to be first verified by the measurement of this new base. Every field is surrounded with a ditch, in cleaning of which the earth and mud are continually thrown out on each side, whereby flat dikes are gradually formed on either side. That the measurement might be carried on as nearly as possible in the same plane, that is to say, about fifteen or eighteen inches above the common surface, therefore narrow grooves were cut in these flat dikes, which the different farmers readily consented to without murmuring. Here it is to be observed, that there was no occasion for levelling the line, Romney Marsh having been formerly covered by the sea, and a considerable part of it, particularly towards the bottom of the range of hills that separate it from the Wealds of Kent, being still lower than the sea at high water, would again be overflowed by it, if much care and expence were not annually bestowed in securing and repairing the dikes, whereby it is protected. Thus the line of the base may be considered as an inclined plane, descending gradually about five feet from the mouth of High Nook pipe to within 246 yards of the Ruckinge end, where the ground in that direction seems to be the lowest. Thence it rises comparatively suddenly, about fifteen feet, to the mouth of the pipe situated in a small field immediately adjoining to Ruckinge Churchyard.

Result of the Measurement.

25. Lieutenant Fiddes, in the course of his trigonometrical survey, and of the different measurements he had actually made of the line with a common iron chain, which from time to time was

plain, compiled by himself from actual surveys, where the names and boundaries of the *waterings*, and many other curious particulars, are very distinctly expressed.—Our plan of the base has therefore derived advantage by adhering to such respectable authority.

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compared with standard rods of deal, had determined the total length of the base within a few feet of the truth, before the ultimate operation began. He had likewise driven into the ground, at the end of every thousand feet, a strong picket, which were numbered 1, 2, 3, &c. from the pipe at High Nook to the 28th near Ruckinge. In all this preparatory part of the business he had no other assistants than the artillery-men of his surveying party. But for the ultimate determination, the aid of some person in whom he could confide for the management of the operation in general, and particularly for the adjustment of the scale at one end of the chain, while he himself was adjusting that at the other was absolutely necessary; therefore Lieutenant Bryce, of the Royal Artillery (now of the corps of Royal Engineers), an attentive officer, and mathematician, was left with him for those essential purposes. These two gentlemen began the operation on the 15th of October, and after experiencing many difficulties, arising from the badness of the weather in that late season of the year, and the defectiveness of the apparatus, it was only by dint of great labour, and the utmost perseverance, that they were enabled to accomplish the measurement on the 4th of December following.

The annexed table of the base, which contains three columns, shews the progress that was made in the work from day to day. The first column contains the date; the second, the spaces measured each day, reckoned by hundreds of yards, and denoted in the general plan by strong dots; and the third shews the temperature of the chain deduced from the mean of fifteen thermometers, or five for each chain.

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Table of the Measurement of the Base of Verification on Romney Marsh, executed in the Autumn of 1787.

Days.	Spaces measured. Yards.	Mean temp. by 15 therm.	Days.	Spaces measured. Yards.	Mean temp. by 15 therm.	Days.	Spaces measured. Yards.	Mean temp. by 15 therm.
Oct.		°	Nov.		°	Nov.		°
15	100	54.7		3100	50.9		6100	42.1
16	200	62.7	2	3200	49.1		6200	39.3
	300	61.3		3300	50.4	21	6300	43.3
17	400	57.0		3400	48.5		6400	46.5
	500	52.2		3500	42.6		6500	45.6
	600	53.6	5	3600	52.3	22	6600	42.5
20	700	46.8		3700	53.0		6700	42.2
	800	58.9		3800	52.4		6800	41.2
23	900	53.9		3900	47.3	23	6900	39.8
	1000	55.3	7	4000	55.6		7000	39.0
24	1100	55.7		4100	55.2		7100	37.7
	1200	50.0	10	4200	55.3	24	7200	36.2
	1300	55.2		4300	53.6		7300	42.1
26	1400	59.1		4400	49.0		7400	40.5
	1500	60.0	12	4500	50.1	26	7500	35.2
27	1600	59.1		4600	47.9		7600	39.8
	1700	63.1	13	4700	44.7		7700	38.5
	1800	68.1		4800	44.8	27	7800	33.6
	1900	57.9		4900	41.3		7900	38.9
29	2000	60.8	14	5000	41.8	28	8000	32.7
	2100	65.0		5100	42.9		8100	36.3
	2200	64.1	15	5200	45.3		8200	39.2
	2300	56.7		5300	44.1		8300	39.5
30	2400	58.7		5400	40.4	29	8400	34.8
	2500	59.5	16	5500	41.5		8500	40.5
31	2600	57.3		5600	44.8		8600	42.3
	2700	54.6		5700	44.6	30	8700	30.5
Nov.	2800	53.9	17	5800	40.6		8800	44.3
1	2900	49.0		5900	39.4	Dec.	8900	46.0
	3000	54.0		6000	41.3	1	9000	43.0
							9100	45.6
							9200	48.7
						3	9300	41.1
							9400	46.9
						4	9512.2454	48.4
								4552.7

By the table, it appears that the total apparent length of the base, as given directly by the chain, was 9512.2454 yards, or 285.36736 chains = 28536 feet, 8.835 inches.

But when the new points, at the distance of 25 feet from each other, were laid off on the chain in Mr. Ramsden's shop, from the original points on the great plank of New England deal, the temperature was 55°. *The original points here alluded to* (by General Roy), *must be those mentioned in the account of the Hounslow Heath base* (5), *which were fixed in the plank, from the brass standard, in the temparature of* 63°.* Therefore, as the chain in the temperature of 55° was equal to 100 feet of the brass standard in that of 63°, it follows from the table of expansions (p. 88.) that its length in $53^\circ\frac{4}{10}$ was equal to 100 feet of the brass standard in 62°; and consequently $53^\circ\frac{4}{10}$ is the temperature to which the measurement by the chain must be reduced. Now the sum of all the degrees, shewn by the thermometers being $4552.7 \times 15 = 68290.5$; and the apparent length = 285.36736 chains, we have $\overline{285.36736 \times 53\frac{4}{10} - \frac{68290.5}{5}} \times .00763$ inch. = 12.8 inches, the contraction below $53^\circ\frac{4}{10}$. This correction to be *subtracted* from the apparent length.

Previous to the measurement, the length of the chain was laid off, in the temperature of $55^\circ\frac{1}{2}$ on St. James's churchyard wall, two brass pins being fixed in the coping for that purpose. After the measurement on Romney Marsh was finished, the chain, in the temperature of 39°, being stretched out on the wall, it fell short of the original points in the brass pins by $\frac{103}{1000}$ of an inch. Now $55^\circ\frac{1}{2} - 39^\circ = 16^\circ\frac{1}{2}$, and $16\frac{1}{2} \times .00763 = 0.126$ inch. Hence $0.126 - \frac{103}{1000} = 0.023$ inch, is what the chain had lengthened during the measurement: half of this, or 0.0115 multiplied by 285.37

* The chain was tried against the new ones when the base on Hounslow Heath was re-measured in 1791: from whence it appeared that 63° must have been the temperature; nearly.

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(chains) gives 3.282 inches. This correction to be *added* to the apparent length.

	Feet.	In.
Apparent length, - -	28536	8.835
Correction for contraction of the chain, - *sub.*	1	0.8
Correction for the wear of the chain, - *add.*	0	3.282
Correction for two hypothenusal distances; the Ruckinge end of the base being suddenly elevated 15 feet above the lowest part, - *sub.*	0	3.023
Correction for height of the base above the mean level of the sea, supposed to be about $15\frac{1}{2}$ feet, *sub.*	0	0.166
Length of the base in the temperature of 62° of Fahrenheit's thermometer, or the length, supposing it had been measured with the brass standard in that temperature, - -	28535	8.128

As a proof that the expansion of the chain was accurately determined, I shall close this article with a remark repeatedly made by the two gentlemen entrusted with the execution of this last measurement. At the close of each day's work, the two scales marking the extremities of the last chain (after registering the divisions of coincidence) were left upon their respective posts until the next morning. They were secured during the night, from being disturbed by cattle, with a certain number of the spare posts driven into the ground around them. A tent was also pitched between the two, where some men of the party constantly lay, by way of a guard for the whole apparatus. On the recommencement of the operation the subsequent morning, the chain being applied anew to the brass scales; if the temperature continued the same, the coincidences were found to be equally accurate as on the preceding night; but if it had changed one or two degrees, the chain never failed unequivocally to shew it, by falling short of

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the divisions on the scales, if the cold had increased, or by over-reaching them, if it had diminished.

Finally, with respect to the subject of these bases, it is here to be remarked, that the base of verification in Romney Marsh makes with the meridian of the pipe at High Nook an angle of 54° 28′ 56″ north-westward; and *that* on Hounslow Heath makes with the meridian of the pipe at Hampton Poorhouse an angle of 44° 41′ 49″, also north-westward. But those bearings are determined by computation, and therefore cannot be considered as very correct.

General Description of the great Instrument with which the Angles, in the recent Trigonometrical Operation, were observed; shewing also its various adjustments for practice. Reference to be had to Plate VIII. *a general View of the entire Machine; Plate* IX. *a Plan and two Sections; Plate* X. *various Parts represented to large scales; and Plate* XI. *the Microscopes and Eye-pieces.*

Preamble.

26. In endeavouring to describe the curious instrument made use of for observing the angles in the recent trigonometrical operation, it has been judged best to confine ourselves to the principal parts, without entering into any detail of the *minutiæ:* for even to have mentioned these, with the almost infinite number of little screws that serve to unite them into one entire machine, which could only have been done by references to a multitude of great and small Roman and Greek characters, would have been a disgusting labour. By the help of the four plates which this description refers to, and which have been executed with great care, that fewer words might suffice, it is hoped, that the instrument may be understood by two classes of people for whom it is chiefly intended; first, by those who being possessed of such a machine,

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would wish to make themselves masters of its use; and, secondly, by such ingenious artists as would attempt to construct such another; for these last, in particular, the parts that are of brass, of bell-metal, or of steel, are distinguished from each other. And here it is necessary to observe, that the plates must not only be frequently consulted, but also attentively considered, and repeatedly compared with each other, in the course of this description.

General View of the Instrument.

27. It is a brass circle, three feet in diameter, and may be called a great Theodolite, rendered extremely perfect; having this advantage in particular, which common theodolites have not, that its transit telescope can be nicely adjusted by inversion on its supports; that is to say, it can be turned upside down, in the same manner that transit-instruments are, in fixed observatories.

The circle is attached by ten conical tubes, as so many *radii*, to a large vertical, conical hollow axis, of twenty-four inches in height, which may be called the exterior axis. Within the base of this hollow axis, a collar of cast steel is strongly driven; and on its top there is inserted a thick bell-metal plate, with sloping cheeks, which, by means of five screws, can be raised or depressed a little.

The instrument rests on three feet, which are firmly united to each other at the place where they branch off, by a strong circular plate of bell-metal, upon which rises another vertical hollow cone, of less size than the former, being included within it, and is therefore called the interior axis. On its top is inserted a cast-steel pivot, with sloping cheeks, passing through the bell-metal plate on the top of the exterior axis, the cheeks of the one being nicely ground to fit the cheeks of the other. The bell-metal base of this interior axis is in like manner ground to fit the cast-steel collar in the base of that which is without it. Thus the circle being lifted

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up by two men laying hold of its *radii*, and the exterior being placed upon the interior axis, the cheeks at the top being at the same time adjusted to their proper bearing, it turns round very smoothly, and is perfectly, or at least as to sense, free from any central shake. This mode of centering is one of the chief excellencies of the instrument. From the use that has been made of it both years, it seems not to have suffered in the least; and it is perhaps the only construction that could have answered for a machine of such magnitude, undergoing so many quick transitions from place to place, and so often raised to high situations without any risk of being thereby hurt.

Mahogany Planes under the Instrument.

28. By inspection of the plates, but more particularly the VIIIth, and the section towards the right hand in the Xth, it will be seen, that there are three planes of mahogany under the metal parts of the instrument; namely, that which forms the top of the stand, which, although a square of about three feet four inches at bottom, becomes, by the separation of the legs, an octagon at top. In the centre there is a circular opening of nine inches diameter, the use of which will appear hereafter. Over the top of the stand lies another plane of mahogany, likewise an octagon, of somewhat greater dimensions than the former, with a circular curb running around it, about half an inch within the planes of its sides. This octagon hath in its centre an open conical socket of brass, three inches in diameter; and on four of its opposite sides there are fixed four strong brass screws, one on each side, which acting against pieces of brass, inlaid into the opposite sides of the top of the stand, the octagon plane, with every thing that rests on it, may thereby be moved in four opposite directions, until the plummet suspended from the centre of the instrument above, is accu-

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rately brought to coincide with the point marking the station underneath. The third or uppermost plane of mahogany is in fact a part of the instrument itself, being at all times by screws or otherwise united to it, and carrying the handles whereby it is lifted out for use, or in again into its case, to be transported from place to place. In the middle of this plane or bottom to the instrument, there is another conical brass socket, of three inches and a quarter in diameter, fitted to slip over and turn easily on that in the centre of the octagon underneath. In the brass cover of this socket, there is a very small hole concentric with the instrument, to suffer the thread or wire to pass, which suspends the plummet; and in the view, Pl. VIII. may be seen another small box that contains the thread, with a winch-handle for raising or lowering the plummet, according as the height of the instrument above the station on the ground, or edifice where it stands, may require.

Feet Screws for levelling the Instrument.

29. By attending to the group representing the front elevation of the feet screws, with its side nuts, in the right-hand upward angle of Pl. X. it will appear, that they are slackened, which is always the case before the instrument is levelled, to give room for that operation by the action of the screws. This being done, the side nuts are brought to press gently on the horizontal plate that embraces the whole group, and thereby keeps the instrument as it were united to the mahogany until some fresh adjustment becomes necessary. When the instrument is to be put into its case, then the feet are let down, and by the side nuts the horizontal plate is brought to press strongly on the whole group, whereby it is kept perfectly fast and secure from motion, in carrying from one situation to another.

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Blocks of Box Wood and conical Rollers under the Feet Screws.

30. By referring also to Pl. X. it will appear, that directly below each foot there is fixed to the lower surface of the mahogany a small block of box wood, curvilinear in the direction of its motion. On these three blocks rests the whole weight of the instrument, which nevertheless can be moved circularly on them alone. But to render the motion perfectly easy, three conical brass rollers, placed somewhat nearer to the centre, are, by means of their respective springs and regulating screws, brought to act and receive such a proportion of the weight as it may be necessary to lay upon them. The head of one of these screws, which give more or less action to the rollers, may be seen at D in the principal view of the instrument Pl. VIII. as well as in the plan and section Pl. X.

Screws giving Motion to the whole Instrument.

31. By examining attentively the general view of the instrument, may be seen, in two positions, the great screw with the flat ivory head, whereby the entire machine received a circular motion. In one, it is attached to the curbs, as when in use in 1787; in the other, it is laid upon the mahogany bottom, as was the case the same year every time it was carried to a new situation. But this ivory-headed screw having been found to act by jerks in moving so great a weight, and consequently to be troublesome in adjusting the instrument to the fixed point, or that of commencement in measuring angles; it was therefore laid aside in 1788, and another apparatus or clamp was adapted for the same purpose. This last may be seen attached to the curbs, as represented towards the right hand of Pl. X. It consists of a brass cock, fixed to, and projecting outwards from, the curb of the instrument; which cock is

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acted upon by two screws working on the opposite sides against it, and which are clamped to the curb of the octagon.

Mahogany Balustrade and Cover.

32. The curb, whereon the three feet of the instrument rest, carries a balustrade of mahogany fitted to receive, on the top thereof, a mahogany cover, no where represented except in the two sections in Pl. IX. In this cover there are only four small openings (besides that which allows the great vertical axis to pass), *viz.* one for each vertical microscope, one for the clamp of the circle, and one for the socket of the Hook's-joint. The two last are less than the former. At the same time that this cover effectually secures the circle with its cones from dirt and from accidents, it serves conveniently for laying the Hook's-joint upon, or any thing that may be constantly wanted near at hand; but more particularly for placing the lanterns used at night, for reading off the divisions on the limb of the instrument that come immediately under the vertical microscopes.

Achromatic Telescopes.

33. Two achromatic telescopes, each of thirty-six inches focal length, with double object-glasses of two inches and a half aperture, belong to the instrument. They are excellent of their kind, and are furnished with eye-pieces of different magnifying powers, for erect as well as inverted vision. The lower telescope lies exactly under the centre of the instrument, and is directed through one of the openings of the balustrade. Being only used for terrestrial objects, it requires but a small elevation or depression, and therefore is only supplied with a short axis of seventeen inches in length, supported by braces attached to the feet. The eye end of

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this telescope is purposely made heavier than the object end; and resting on an horizontal arm, that is raised or depressed by rack-work, it is thereby readily brought to bear, and remain very steadily, upon its object. The rack-work may be seen in the view of the instrument, and also on the left side of the right-hand section in Pl. IX. But there is a small horizontal motion that can be given to the right-hand end of the axis of this telescope, which is effected by means of a handle inserted through the vacancy of the balustrades, and placed on a dovetail at E, which could not be shewn in the plate. Thus the instrument being nicely levelled, the upper telescope at zero, and likewise on its object, the lower telescope, by the help of this adjustment, is brought accurately to the same object, supposed to be the point of commencement, or that from which angles are measured.

By referring to Pl. VIII. and IX. and likewise to the section on the left side of Pl. X. It will be seen, that a horizontal bar extends across the top of the vertical axis, supported by two side braces that spring from the cone, about one-third of its height above the plane of the instrument. The horizontal bar carries the Ys or supports, in which the pivots of the upper telescope move. They are of such height as to permit a semicircle of six inches radius, attached to the axis of the transit, to pass freely, and consequently the telescope to be directed to the sun or stars in high elevations, but not to be brought to the zenith. The arc of excess of the semicircle likewise admits of several degrees of depression being measured thereon.

Spirit-Levels.

34. The instrument has two very good spirit-levels, that are fitted with the several means of adjustment, as is usual in such cases, the detail of which it is unnecessary here to enter into.

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The first, or axis level, because it is only applied on the axis of the telescope, is that whereby it is set horizontal, as in the ordinary transit instrument; and it is likewise used for placing the conical axis truly vertical, so that the instrument may turn round without sensible alteration of the level, previously to observations of the pole-star, or of other heavenly bodies.

The second, or elevation level, is that whereby the telescope is brought to be truly horizontal, when angles of elevation or depression are to be taken. At such times it is suspended on a rod attached to the outside of the telescope, to whose axis of vision the rod, by adjustment, can be made parallel, as will readily be conceived, by observing the representation of these parts in the right-hand section of Pl. IX.

When the angles of elevation or depression to be determined are very small, they are measured by the motion of an horizontal wire in the focus of the eye-glass of the telescope; but, when great, their quantity is measured by the arc of motion of the semicircle, as shewn by its proper horizontal microscope.

The elevation level is likewise made use of for levelling the instrument when horizontal angles only are to be taken, for which purpose it is suspended on two pins, which are seen projecting from the horizontal bar in the plan, and one of them in each of the sections in Pl. IX. This was the ordinary position of the elevation level when the angles of the triangles were observed, and thereby it was easily seen in the course of the operation, whether the instrument had suffered any change to render a re-adjustment necessary.

Lanterns for illuminating the Wires.

35. The axis of the transit telescope is hollow, and in the middle there is placed, at an angle of 45° with the axis of vision, a perfo-

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rated elliptical illuminator for throwing light on the wires in night observations. The light is communicated from a small lantern attached to the horizontal bar at its junction with the brace, directly opposite to the end of the axis, which has a bit of thin glass placed before it to prevent dust from entering. There is another such lantern for the lower telescope, not however represented in the plate. As the light given by these lanterns was found to be rather too weak, especially that for the upper telescope, therefore it was customary in practice to illuminate the wires, by holding up frontwise one of those seen in the section in Pl. IX. against the end of the axis of the upper telescope, when directed to the pole-star. The same method was used by presenting it obliquely to the object-glass of the lower telescope, when it became necessary to examine whether the intersection of the wires continued without sensible variation on a reverberatory lamp, commonly placed twelve or fifteen miles off, and sometimes even at the great distance of twenty or twenty-four miles.

Lanterns for throwing Light on the Divisions of the Instrument.

36. Besides the two small lanterns for illuminating the wires of the telescopes in night observations, two larger ones may be seen, as already mentioned, standing on the mahogany cover in the section in Pl. IX. used for reading off the divisions of the instrument under the vertical microscopes. The front of one of these is shewn, and the back, or that to which the handle is fixed, of the other. Their narrow sides are presented towards the microscopes, there being in each a silvered reflector of copper at FF; and opposite to it, at GG, a screen of talc or transparent oiled paper. The light from a wax candle being thrown on the reflectors, and thence back again through the screens, on the divisions of the instrument under the microscopes, these could be very distinctly read off and registered: for the light communi-

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cated in this way was very strong, at the same time that the glare of it, which otherwise would have been disagreeable to the sight, was removed by passing through the screen.

Arms projecting from the bell-metal Plate under the Plane of the Instrument.

37. By referring to Plates VIII. and IX. but more particularly the latter, it will be perceived, that there are three flat arms, strongly fixed by screws to the edge of the circular bell-metal plate, forming, as has been already mentioned, the basis of the interior vertical axis. These arms, which are also firmly braced to the feet of the instrument, rise gradually as they project outwards towards the circumference of the circle, whose radius they exceed about an inch and a quarter, and their extremities are about an inch lower than its upper surface. One arm, lying directly over one of the feet, is that to which are attached the wheels and screw moved by the Hook's-joint, and also the clamp of the circle, as represented in Pl. X. The other two arms, whereof one lies also over a foot, and the other directly opposite to it, become thereby a diameter to the circle, having their extremities terminated in a kind of blunted triangular figure, forming the bases of pedestals whereon stand the vertical microscopes hereafter to be described. The arms, together with the horizontal bar and braces carrying the transit telescope, are every where pierced, in order to lessen the weight, without diminishing the strength of the parts.

Vertical Microscopes.

38. Two vertical microscopes, distinguished A and B, are used for reading off the divisions on the opposite sides of the circle immediately under them. They are exactly of the same construction, and the chief parts of that marked A are represented in their

real dimensions towards the left hand of Pl. XI.; where, beside the general, may be seen particular plans of the slides, and also that of the pedestal, containing within it the gold tongue, with its axis and screws for adjustment. Next to these plans stand the elevation and optical lines, shewing the position of the glasses, with the magnified scale at the bottom.

Each microscope contains two slides, one lying immediately over the other, their contiguous surfaces being in the focus of the eye-glasses. The uppermost, or that nearest the eye, is a very thin plate of brass, to the lower surface of which is attached the fixed wire, having no other motion than what is necessary for adjustment, by the left-hand screw to its proper dot, as hereafter to be explained.

The steel slide immediately under the former is made of one entire piece, of sufficient thickness to permit the micrometer screw, of about 72 threads in an inch, to be formed of it. To its upper surface is fixed the moveable wire, which changes its place by the motion of the micrometer head, seen in the plan and elevation towards the right hand. The head is divided into 60 equal parts, each of which represents one second of angular motion of the telescope. By examining the particular plan of this steel slide, it will be seen, that it is attached by a chain to the spring of a watch, coiled up in the usual manner, within a small barrel adjacent to it in the frame. By this provision no time whatever is lost; the smallest motion of the head being instantly shewn, by a proportionable motion of the wire, to one hand or the other, in the field of the microscope.

It is necessary to remark, that the whole microscope between its pillars can be raised or depressed a little more or less, with regard to the plane of the circle, by the help of two steel levers, seen one on each side of the elevation, which for that purpose are applied in the holes represented above and below the projecting

plate that unites the tops of the pillars. By means of this motion, distinctness is obtained at the wires; and by the motion of the proper screw of the object lens, which necessarily follows that given to the whole microscope, the scale is so adjusted as that fifteen revolutions of the head shall move the wire over fifteen minutes, or one grand division, on the limb, equal to nine hundred seconds, each degree on the circle being only divided into four parts. This operation being delicate, requires great patience and many repetitions, before the purpose can be exactly, or even nearly, effected: for at the same time that the fixed wire must bisect the dot on the gold tongue, the moveable wire must also bisect the dot at 180° on the limb, as well as the first notch in the magnified scale at the bottom of the plate, where the minutes in the field of the microscope are represented in the proportion of between fifteen and sixteen to one, as painted on the eye of the observer. In this adjustment there is yet another circumstance to be attended to, which is, that sixty on the micrometer head should stand nearly vertical, so as to be conveniently seen. A few seconds of inclination to one side or the other are of no moment, because the dart or index being brought to that position, whatever it may be, must at all times remain there without alteration, unless some derangement that may have happened to the instrument, in transporting from one place to another, should have rendered a fresh adjustment necessary. But if, when the wires coincide with their respective dots and the first notch, sixty on the micrometer head should happen to be underneath, or so far over from the vertex on either side as to be seen with difficulty, then the gold tongue must be moved a little by means of the capstan-headed screws, which act against each other on the opposite extremities of its axis. Thus, by repeated trials, the wished-for object will at length be effected, that is to say, sixty, to which the dart is to be set, will stand in a place easily seen. But it is

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not to be expected, that each microscope will give just nine hundred seconds for the run of fifteen minutes. Without great loss of time this cannot be done; besides that two observers, of different sights, will adjust the microscopes differently. Accordingly, in 1787, after many trials of the runs in measuring fifteen minutes on the different parts of the limb, microscope A was found to give only 896″, while B gave at a medium 901″. But in 1788, microscope A gave 900″, while B gave no more than 894″. These differences were of course registered and allowed for in the estimation of the angles for computation, whereby any difference between them almost wholly disappeared.

The gold tongue, which is extremely thin, applies very closely to the surface of the circle. In the plan it is supposed to be seen through a thin plate of brass, covering the whole pedestal, and also through a small square plate lying over the former, and fastened to it by three screws. In the under side of this last, there is a cavity for the projecting part of the tongue. This contrivance of the tongue with its dot was to guard against any error that might arise from accidental motion given to the instrument between one observation and another, which from this precaution could never happen, without being immediately discovered; for the wires being adjusted to their dots under the microscopes respectively, if the instrument be then turned round 180°, the wires will reciprocally bisect the dots that were originally opposite to them, and thereby shew, that they are accurately in the diameter of the circle; and so on with regard to any other dots whatever. Hence this becomes the most severe mode of trying the justness of the divisions of the instrument.

Manner of reading off Angles with the Microscopes.

39. By attending to the magnified scale at the bottom of the plate, it will appear, that the dot on the gold tongue, which is

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here inverted, is about one minute to the left of zero, and also of the first notch, with which the moveable wire alone coincides. Now it will easily be conceived, from what has been said in this description, how readily, as well as accurately, any observation of an angle can be read off with such an instrument; for the degrees and quarters, that is to say, the 15′, 30′, or 45′, being seen with the naked eye, and registered, the value of the fractional space between zero and the last past grand division, seen in the field of the microscope, is obtained by turning the micrometer head until the moveable wire bisects the dot at that grand division. The number of notches towards the right hand passed over on the scale, equal to so many revolutions of the head, are the number of minutes, always less than 15′, to be added. If there be no odd seconds, the dart will then stand at 60 on the head; but, if any number of seconds are to be added, the dart will shew, by its position with regard to 60, what that number is. Thus, by adding the parts together, the measure of the total angle is obtained.

The construction, adjustment, and application of these vertical microscopes have been given more fully, because they form a most essential part of the instrument: for the fixed wire constantly remaining on its dot, the fractional space may be repeatedly measured many times over, if necessary, and a mean result may then be taken. But it rarely happens that two observers, reading off with the opposite microscopes, differ more than half a second from each other at the very first reading. If time therefore permits, and the circumstances of the weather should also be favourable for repeating the observation with the telescope, it is sufficiently obvious to what a wonderful degree of accuracy the measure of angles may in this way be obtained.

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Horizontal Microscopes.

40. Besides the two vertical microscopes, applied in the manner that has been described to the measurement of the fractional space in horizontal angles, there is yet another to be mentioned, which is placed horizontally on the bar that carries the transit telescope, and is directed to the divisions on the semicircle attached to its axis, for the measurement of angles of elevation or depression, as has already been taken notice of. This microscope, which is of the same construction with the others, but larger, being upwards of nine inches in length, is represented in its full dimension in Pl. XI. It has, like the others, a slide made of steel, of such thickness as to permit the micrometer screw to be formed of it; and it carries a vertical wire placed in the focus of the eye-glasses, in which position it is moved parallel to itself from left to right, by turning the micrometer head. This slide is also attached to a watch spring, which acts in a contrary direction to the head, as in other microscopes of this sort.

Each degree of the semicircle being divided into two parts, or 30′, and one revolution of the micrometer head moving the wire in the field of the microscope 3′; therefore in 10 revolutions it changes its place half a degree, or 30′, which are shewn by a scale of 10 notches in the upper part of the field of the microscope, and also represented towards the top of the Plate. Each notch corresponds to 3 minutes or 180 seconds, and the head being divided into 3 minutes, and each minute into twelve equal parts, therefore each part is of the value of five seconds.

Concerning the Semicircle.

41. With regard to the semicircle, which has been repeatedly mentioned in the course of this description, it is yet necessary to make some remarks; and particularly to shew how, by its means,

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the axis of vision of the telescope, when adjusted, is brought and kept truly horizontal, which is effected in the following manner.

On the opposite sides of the horizontal bar that carries the telescope there are fixed four small, but finely polished bell-metal planes, two on each side, on the right and left of the top of the vertical axis, in such a manner as that the surfaces of the two on either side are directed to, or in the same plane with, the centre of the axis of the telescope. These planes will be best conceived by observing attentively the top of the vertical axis in the section towards the right hand of Plate IX. On the edge of the semicircle may likewise be seen a moveable clamp, easily made to slip, with the hand only, around its circumference, and it carries with it a very fine steel screw. When the semicircle is towards the left hand of the telescope, which is its ordinary position, the point of the steel screw rests, or may be made to rest, perpendicularly on the surface of the plane that is on the left of the vertical axis. But when the telescope is inverted in its Ys, or turned upside down, as is the case in adjusting the line of collimation, the semicircle being then on the right of the telescope, and the clamp necessarily brought down, the point of the steel screw accordingly rests perpendicularly on the surface of the plane to the right of the vertical axis. Thus it will be readily conceived, that in adjusting the telescope by the level for elevations, which is then constantly suspended on its proper rod, parallel to the axis of vision, the action of the steel screw on the bell-metal plane serves not only for the adjustment of the telescope in a truly horizontal position, for angles of elevation or depression, by the motion of a wire in the focus of its eye-glass, in the manner hereafter to be described, but also to keep it in that position, by the superior weight of the eye end, rendered so on purpose. By the same means the telescope remains steadily on any object that it may be directed to for intersection, whether above or below the plane of the horizon.

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Eye-glasses of the Telescopes, and Mechanism of the Wires in their Foci.

42. It has been already mentioned, that the telescopes of the instrument are furnished with eye-glasses of different magnifying powers for erect and inverted vision, six for each telescope, as follows, *viz.*

	Erect vision.		Inverted vision.	
	No.	Power.	No.	Power.
For the lower telescope,	1.	58.	1.	43.
	2.	88.	2.	59.
	3.	117.	3.	87.
For the upper telescope,	1.	54.	1.	40.
	2.	81.	2.	55.
	3.	108.	3.	80.

With regard to these eye-glasses, it is only necessary here to mention, that those of the least magnifying powers were found both in day and night observations to answer the best.

In the focus of the eye-glass of the lower telescope there are only two wires crossing each other in acute angles, which are vertical, instead of being placed at right angles, horizontally and vertically, as was the ancient method. Since the lower telescope never moves through more than a few degrees of a vertical arc, the wires require little or no adjustment. Nevertheless this was provided for, by allowing room for a small circular motion of the end-piece, which, when adjusted, is then fastened by its proper screws, and never afterwards needs any alteration.

By referring to the middle part of Plate XI. two representations of the eye end of the upper telescope will be seen, with the eye-piece removed. Five wires are shewn in this end, namely, two that intersect each other in acute angles, similarly to those

in the lower telescope; and three that lie horizontally or parallel to each other. Four of these, *viz.* the two that form the acute angles, and the two extreme horizontal wires, are fixed in the focus of the eye-glasses to the farther surface of a thin brass slide, supposed to be seen through the outward brass, and therefore shaded more dark than the rest. This slide, as will be conceived, lies nearest the eye, and is moveable from right to left, and, *vice versâ*, horizontally, for the adjustment of the line of collimation, by the insertion of a small mill-head key, on a square pin fitted to receive it, and secured by a socket on the right-hand side. The fifth or middlemost horizontal wire is attached to the nearest surface of a steel slide, that lies contiguously to, but beyond the former. It is made of one entire thick piece, like those of the microscopes, to permit the micrometer screw to be formed of it; and it is represented in the uppermost figure attached to a watch spring coiled up in the usual manner.

By the motion of the micrometer head, the slide, and with it the wire, moves upwards or downwards in the field of the telescope, a space equal to half the distance of the extreme wires from each other. This motion above or below the central point, which was made to correspond with the acute intersection of the wires placed in the axis of vision of the telescope, is performed in ten revolutions of the head, as denoted by the motion of the dart, ten divisions upwards or downwards, in the narrow groove seen at the top of the figure.

Now, by the means of this piece of mechanism in the eye-end of the telescope, it will appear sufficiently obvious, that small angles of elevation or depression may be determined with great accuracy, when the value of a certain number of revolutions and parts (the circumference of the head being divided into 100) have been once ascertained by repeated observations of the altitude of any well-defined object taken by the semicircle. Thus it was

found, by experiment, that $7\frac{77}{100}$ revolutions of the micrometer head were equal to an angle of elevation or depression of $10'\ 59''$ or $659''$, on the semicircle. Whence it follows, that one revolution raises or depresses the wire above or below the central point $1'\ 24''.8134$, or a little more than $84''81$. And hence a motion of one division on the head raises or depresses the wire nearly $\frac{85}{100}$ of a second.

In this manner were determined the reciprocal elevations or depressions of the several stations of the series of triangles with regard to each other.

By observing attentively the four screws represented in the outward end of the telescope, a dotted groove will be seen under the head of each. And in the uppermost figure there appears a flat brass ring, soldered to the inside of the tube about half an inch from the outward end, which carries on its surface four studs to receive the lower extremities of the four screws. Thus the grooves allow room for a small circular motion to be given to the end-piece for the vertical adjustment of the fork of the wires, those that are horizontal being by construction at right angles with it. This being done, the screws are made very fast in the studs below, and thereby the whole machinery of the end-piece is rendered perfectly firm and secure.

There remains yet one piece more to be barely mentioned. It is the prism eye-tube, represented by dotted lines towards the right-hand side of Plate XI. as attached to the eye end of the transit telescope, instead of the common eye-piece with two convex glasses. In leaning over our instrument to observe the pole-star, highly elevated in these latitudes, the body is necessarily thrown into an inconvenient fatiguing posture, whereby some risk is run of deranging the instrument, and consequently of making the observations less accurately than when the observer can look directly forward, without bending the body so much. For this

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purpose; Mr. Ramsden promised to supply the prism tube in 1787; but it was not obtained till 1788, by which time Mr. Dalby had accustomed himself to observe very well without it, so that it was never used.

By employing this piece, light is no doubt lost; because the image passes through more glasses before it reaches the eye, than when the common eye-piece is used. But for observations of stars nearer the zenith than the pole-star is in our latitudes, it would be indispensably necessary. It would likewise be advantageously used in looking at the meridian sun in summer, for which purpose it is furnished with dark glasses, placed in a slide moved by rack-work, as may be seen from inspection of the plate. They consist of three prisms, laid close to each other, so as to form, when thus assembled, a parallelopiped. Here the green prism stands nearest to the eye, a dark one farthest from it, and between the two, one of white flint glass, for correction of the refraction which would otherwise take place. It will easily be conceived, from the disposition of the prisms, that the darkest medium is here towards the left; and that it becomes gradually lighter towards the right hand, where a void part in the frame is brought into the field when the stars are observed; or when, from the circumstances of the weather, it may be unnecessary to screen the eye from the sun's rays.

General Management of the Instrument for Observation.

43. When the instrument is used on the ground, it is covered from the weather, under a circular tent, eight feet in diameter. Four short piles, hooped and shod with iron, are driven into the earth, and their heads levelled, by laying across from one to the other a mahogany straight ruler, having a spirit level attached to one side of it. The feet of the stand being then placed on piles,

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are firmly fastened to them by means of long square-headed screws, only one of which may be seen in the view of the instrument, belonging to that foot which stands nearest the eye. By working with the four screws fixed in the octagonal mahogany plane, the plummet suspended from the centre of the instrument is brought accurately over the point on the ground that marks the station. The screws of the feet, with the side nuts appertaining to them, are then slackened, to give sufficient room for the adjustment of the instrument, which by them is brought to be level.

Adjustment of the Axis Level.

44. The axis of the upper or transit telescope being brought over any one of the feet, and the circle being clamped, hang the axis level on the pivots or *ansæ* of the telescope, and bring the bubble to the two indexes; then reverse the level, that is, turn it end for end, and note the difference. Bisect this difference, one half by the level's proper adjusting screw, and the other half by that foot-screw only which is in a line with the axis. This operation being repeated until the difference wholly vanishes, the level will be truly adjusted; that is to say, the bubble will rest between the same points in both positions.

Adjustment of the Elevation Level.

45. This level being suspended on the rod attached to the outside of the transit telescope, screw the erect eye-tube on, to make that end preponderate. Adjust the bubble to the indexes by the steel finger-screw at the tail of the semicircle's clamp. Reverse the level, and note the difference. Then bisect that difference, and correct one half by the finger screw, and the other half by the proper adjusting screw under the level, and so on repeatedly until

the difference wholly vanishes. The level may then be hung on the two pins that project from the horizontal bar which carries the telescope, where, being parallel to the axis level, it will shew when that is removed (as is commonly the case when terrestrial objects only are observed) whether the plane of the instrument suffers any alteration. If this should have happened, the level on the horizontal bar is at all times sufficient to correct it.

To set the vertical Axis perpendicular.

46. This may be done by either level, but best with the axis level, which being suspended on its pivots, must be brought parallel with two of the feet of the instrument; and by the screws of these two feet, the bubble is to be brought between its indexes. The circle being then turned round 180°, if the bubble changes its place, half the difference is to be corrected by one of the feet-screws, and the other half by two capstan-headed screws, that act against each other, under and belonging to one of the Ys or supports, in which the pivots rest. When the bubble is found to be just in these two positions, turn the circle 90°, which will necessarily bring the axis over the third foot of the instrument. Then correct any error there may be by that foot screw. In this manner the circle will be made to revolve again and again, without any alteration whatever of the bubble, which shews that the vertical axis is then truly perpendicular to the horizon.

To make the Line of Collimation in the Telescope at right Angles with the transverse Axis.

47. The pivots resting in their Ys, direct the telescope to some distant well-defined object, and let the circle be clamped. Then reverse the axis, that is, turn the telescope upside down. If the

intersection of the wires does not coincide with the object in both positions, half the difference must be corrected by the motion of the circle with the Hook's-joint, and the other half by the motion of the brass slide in the eye end of the telescope, by applying the milled-head key in the small socket, seen on the right-hand side in Plate XI.; and so repeatedly until the difference wholly disappears.

To set the Rod on which the Elevation Level hangs parallel to the Line of Collimation.

48. The vertical axis being supposed to be nearly vertical, hang the level on its rod, and rectify the bubble by the finger screw of the clamp. Set the horizontal wire on the steel slide, to intersect the centre of the oblique wires, and place the dart or index at zero on the micrometer head. Then observe some distant distinct object covered by the horizontal wire. Take off the level, and turn the telescope upside down; and bring the wire upon, or nearly upon, the same object: then hang the level on again. Now, if the level be not right, rectify it by the finger screw at the tail of the clamp. If the telescope does not now accurately cover the same object as in the former position, bisect the difference by the finger screw of the clamp, and then rectify the bubble by the capstan-nuts under one end of the rod. Repeat this operation until the level is right, when the telescope shews the same objects in both positions, and thereby the rod will be brought parallel in altitude to the line of collimation or axis of vision.

The adjustments of the microscopes having been already sufficiently explained, in giving the description of the essential parts of the instrument, it is unnecessary here to repeat them.

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Of the Weight of the Instrument, and Mode of transporting it from Place to Place.

49. The instrument, whose description and uses we have here attempted to give in a general way, without reference to its minute parts, by a multitude of different characters, weighed in the whole about 200 lbs. It is contained in two deal boxes; one of a circular form for the body of the instrument; and the other of an oblong-square figure, for the transit telescope. Within this last box there is one of mahogany, that holds all the smaller parts of the apparatus. The stand, steps, stools, pullies, ropes, tent, and canopy for the scaffold, &c. &c. weighed at least as much more. The whole attirail was transported from place to place, in a four-wheeled spring carriage, drawn by two, and sometimes by four horses. The carriage part, originally that of a crane-necked phaeton, was presented, with his usual liberality, by Sir Joseph Banks; and upon it was built a kind of caravan, covered with painted oil-cloth, whereby every thing within was kept dry and secure.

Description of various Articles of Machinery made Use of in the Trigonometrical Operation referred to in Plate XII.

Portable Scaffold.

50. In the account of the measurement of the base on Hounslow Heath, we have shewn that the surface of that remarkable plain is not elevated more than fifty or sixty feet above the mean level of the sea. From this small elevation, and the circumstance of its being surrounded, almost on every side, with lofty trees, it was from the beginning sufficiently obvious, that, in order to be

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enabled to make the observations of the collateral stations from the extremities of the base, it would be absolutely necessary to raise the instrument, by some means or other, to a considerable height above the ground. For this purpose the portable scaffold, whose plan and elevation are represented on the left-hand side of Plate XII. was constructed. It consisted, as may be seen, of an inward scaffold for supporting the instrument, and an outward one for the observers, wholly free and independent of each other, the platforms of both being framed about thirty-two feet above the lower ends of the scantlings which rest on the ground. These being made of squared deal, and the several parts being bolted and screwed together with many iron screws secured by nuts, the whole could be readily taken to pieces, carried in a waggon (for which it made a complete load), and replaced again in any new situation. This scaffold answered very well the purpose for which it was intended; for the step-ladders, or stairs leading to the platform, being attached to the outward frame, the inward one that carried the instrument remained undisturbed by the motion of those who went up and down, or walked around the top. The silk thread, that suspended the plummet, was secured from the effects of the wind by a sort of funnel or trunk, composed of three deals (one side being left open), and so contrived as to be easily turned round to any quarter of the heavens, whereby the open side was always presented to leeward. The instrument was covered from the weather by a canvas canopy, about seven feet square, to which side walls could be hooked, for screening it from the wind, as occasion might require. By referring to the elevation it will be seen, that the scaffolds, both outward and inward, might be divided horizontally into two parts, so as to permit the uppermost half alone to be used, when it became unnecessary to raise the instrument to a greater height than fifteen or sixteen feet above the ground. The whole together was never made use

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of, except at the two extremities of the Hounslow Heath base. The uppermost half was applied at three of the stations only, namely, St. Ann's Hill, Botley Hill, and Padlesworth near Dover.

Tripod Ladder.

51. Next to the scaffold the Plate represents, in plan and section, a tripod ladder, about thirty-five feet in height. It carries on its top a globe lamp, of about one foot in diameter, in which was used a simple Argand's burner, of a large size, made for that purpose. The lamp being removed, a socket for a white light might occasionally be substituted in its place; or (as was the case when we observed the station at King's Arbour from St. Ann's Hill) a flag-staff might be added at the top, which was secured in a truly vertical position, by braces fixed to the legs of the ladder underneath. It will be readily conceived, that by a contrivance of this sort a white light could be raised to a considerable height above the ground, if the circumstances at any time had rendered such elevation necessary; and that it could, by the help of a heavy plummet, be always placed in a truly vertical position over the point on the ground marking the station. The globe lamp was found to answer very well for short distances, of six or eight miles, when the weather was favourable; but it could not be depended upon in observations of distances that were considerably greater.

Common Flag-staff.

52. After the tripod ladder, comes in the Plate the plan and elevation of a common flag-staff with its braces, carrying likewise two reverberatory lamps. These two were attached to the same iron bar, at the distance of three feet from each other. They

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had concave copper reflectors, nine inches in diameter, extremely well polished and silvered. They were intended at first for experiments near London, and were very well seen at the distance of fifteen or sixteen miles. To secure us from any uncertainty that might have arisen, by mistaking other lights for our own, one lamp was placed over the other. But when we came afterwards to be better acquainted with the appearance of these lamps, that precaution was found to be entirely unnecessary; wherefore single reverberatories were provided, with *specula* of ten inches diameter, and they were supplied with still larger burners, which could be seen at the distance of twenty or twenty-four miles. But here it is proper to remark, that these lamps must be carefully watched, especially in exposed windy situations; for if the cotton be drawn out a little too far, they are apt to smoke, whereby the front glass becomes obscure, and therefore must be wiped frequently. They are easily turned on the posts that support them; and were, by the help of a telescope laid on one side, parallel to the axis of the rays (for which a contrivance was provided in the tin work) accurately presented towards the station occupied by the instrument at the time from whence they were to be observed. There was constantly one of these lamps, and sometimes two, at two different stations, burning each night, when we were making observations of the pole-star, or white lights, of short duration, placed at other distant stations.

Tripod for White Lights.

53. Next after the flag-staff (whereon a socket for white lights could likewise be placed, when the flag itself was removed) is represented a small tripod intended for white lights only. The same socket that fitted the top of the flag-staff, or lamp-post, could be applied to the tripod, by the help of three small sockets

soldered for that particular purpose to the sides of the principal one. Deal rods, of five or six feet in height, or hazels cut from the nearest hedge, served as the legs of this stand. The sockets themselves were made of copper, because those of iron would have been dissolved by the sulphur; and the upper part, which was only an inch, or an inch and an half, in height, was square or round, according to the figure of the boxes containing the composition, sometimes of one kind, and sometimes of the other. These white-light tripods, being readily placed, by the help of a plummet, over the point marking the station, were found to be very convenient on the top of an open hill, or on the leads of a church steeple, as the person attending them could easily light the box with the port-fire, without the aid of a ladder.

Portable Crane.

54. On the right-hand side of the plate is represented, in plan and section, and by a larger scale than the others, a portable crane for weighing up the instrument to the tops of such towers, church steeples, or other buildings, as became stations in the series of triangles. It was constructed in the Tower of London, and answered very well the purpose for which it was intended, although it might still be improved. Before we were supplied with this crane, we made shift, by the help of a long beam, and a moveable trestle by way of fulcrum for it to rest upon, to get the instrument up to the top of its own proper scaffold, and one that was still higher, erected over the transit-room of the Royal Observatory at Greenwich.

Distinction of the Stations.

55. In the course of the trigonometrical operation, the centre of the instrument has constantly been brought, even almost to mathe-

matical exactness, over the precise point marking the station, whereby reductions to the centre, on account of eccentricity, have been avoided; and the stations have been distinguished, as far as possible, by permanent marks, in such a manner, that, while these remain, the centre of this or any other instrument may be again brought into the same vertical line. By these means our recent observations may be repeated on any future occasion, and connected with others, which it is to be hoped will be made hereafter: for this operation, the first of its kind in Britain, should only be considered as the foundation or commencement of a series of others, which by degrees will be carried to the remotest parts of the Island.

The stations may be distinguished into two sets. First, those which are permanently marked by pipes sunk in the earth; and, secondly, those where the instrument was elevated to the top of some tower, church steeple, or other building. The plans of the platforms of this last set are given in Plate XIII. along with such dimensions as are necessary to shew, with regard to the side walls, the precise spot over which the centre of the instrument was placed. As often as was possible, these situations were further defined, by means of concentric circles described on the leads.

The stations of the first set, marked with pipes, are fourteen in number, *viz.*

Hampton Poorhouse, King's Arbour,	the extremities of Hounslow Heath base.
St. Ann's Hill, -	about the middle on the east edge.
Hundred Acres, -	near the west end of the garden. *
Norwood, - -	towards the Croydon end of the heights.
Botley Hill, - -	in a field belonging to Limpsfield Lodge Farm.

* This spot has since been inclosed, and the pipe is entirely gone.

Wrotham Hill, -	in a field belonging to Mr. Johnston.
Hollingborn Hill, -	in a field belonging to Mr. Duppa.
Fairlight Down, -	347 feet southward from the Windmill, which makes with Fairlight Church, an angle of 105° 53′ 20″.
Ruckinge, - - High Nook, - -	the extremities of the base of verification.
Allington Knoll, -	an artificial mount belonging to Sir John Honeywood.
Padlesworth,	eastward from the Church, in the Broom-field belonging to Mr. Brockman.
Folkstone Turnpike -	westward from the Public-house

The stations of the second set, where the instrument was elevated on buildings, are nine in number, *viz.*

Hanger-hill Tower.

Transit-room of Greenwich Royal Observatory.

North-west turret of Severndroog Castle, on Shooter's Hill.

Swingfield Church Steeple.

North turret of the Keep of Dover Castle.

Lydd Steeple.

Tenterden Steeple.

Goudhurst Steeple.

Frant Steeple.

Excess of the Angles of Spherical above those of Plane Triangles.

56. Since the sum of the three angles of a spherical triangle is greater than two right angles, it follows, that the sum of the three observed angles of each of the following triangles ought to exceed 180°. The fourth column contains the computed excess, or what should have been given by observation, and the fifth, the error in the observed sum.

It had been at first proposed to multiply the observations as much

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as possible, and particularly by successively changing the zero of the instrument to new points, to measure the same angles on different parts of the circle, so as to subdivide any errors that might arise from inaccuracy of division, or shake at the centre. This principle, perfectly good in theory, and which was adhered to as far as the circumstances would permit, was nevertheless found, on many occasions, to be impossible in practice, without sacrificing much more time than we could afford, consistently with the engagements entered into with the French Gentlemen, for the co-operation on the Coast. At particular times, especially in hot weather, there was such a tremulous motion or boiling in the air, that it was only during a very short space, chiefly in the mornings and evenings, that the objects were sufficiently distinct to be observed with accuracy. So difficult it is to do any thing perfectly good in this way, that a whole day has frequently been spent, after watching with anxious care, in obtaining a single one that was perfectly satisfactory! At such times as these it would have been absurd to have attempted to change the zero, which always rendered it necessary to re-adjust the instrument by its levels.

In very favourable circumstances of the weather a good observation by day is preferable to one by the white lights at night; because, in the first case, the observer has time at his leisure nicely to bisect a fine flag-staff, and repeatedly to read off the angle; whereas, in the short duration of the burning of the light, he is somewhat hurried, from the fear of losing some of the lights at other distant stations, if two of them happened to come together, which now and then they did, from the irregularity of the rates of the watches of the artillery-men attending at the different stations. It was, however, by the assistance of the white lights only, that the most distant stations could be rendered visible; and there cannot be a doubt that, in great trigonometrical operations of this sort, they will be universally adopted hereafter.

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Sometimes an observation has been entirely lost, or at least that which had been obtained was not thought a very good one. In such cases, a blank has been left in the column of observed angles, and also in that expressing the error. But no bad consequence has arisen on that account, there being always such other checks from the collateral stations, as to leave nothing doubtful.

The quantity by which the sum of the three observed angles of spherical triangles should have exceeded 180° was found as follows.

Because the excess of the three angles of a spherical triangle above 180° × earth's radius = its area, therefore $\frac{\text{Area}}{\text{earth's rad.}}$ = excess above 180° in seconds, if the area and radius are taken in seconds. Now, 60859.1 fathoms being = 1° nearly, supposing the earth to be a sphere, we get the log. of the feet in a second = 2.0061743, and twice this, or 4.0123486 is the log. of the square feet in a square second. Therefore log. area in feet − 4.0123486 = log. area in seconds; and the log. of the earth's radius in seconds being 5.3144251, we have log. area in feet − 4.0123486 − 5.3144251 = log. area in feet − 9.3267737 = log. excess in seconds; that is to say, *from the logarithm of the area of the triangle taken as a plane one, in feet, subtract the constant logarithm* 9.3267737, *and the remainder is the logarithm of the excess above* 180° *in seconds nearly.*

Calculation of the Triangles, Plate XIV.

	Feet.
57. Base on Hounslow Heath measured with glass rods (17), - - - - -	27404.01
By the re-measurement, in 1791, with a steel chain,	27404.32
Mean length -	27404.2

No. of triangles.	Names of the stations.	Observed Angles.	Spherical excess.	Diff. or error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	° ′ ″	Feet.
I.	Hanger Hill Tower -	42 2 32			42 2 34	
	Hampton Poorhouse	67 55 39			67 55 39	
	King's Arbour -	70 1 48			70 1 47	
		179 59 59	0.29	−1.29		
	The Base between Hampton Poorhouse and King's Arbour - - - - -				— — —	27404.2
	Hanger Hill Tower from { Hampton Poorhouse				— — —	3[illegible]460.4
	{ King's Arbour -				— — —	37921.9
II.	St. Ann's Hill -	44 18 51.5			44 18 51.5	
	Hampton Poorhouse -	61 26 33.1			61 26 33.5	
	King's Arbour -	74 14 35			74 14 35	
		179 59 59.6	0.21	−0.61		
	St. Ann's Hill from { Hampton Poorhouse				— — —	37753.6
	{ King's Arbour -				— — —	34455.2

Hence, in the quadrilateral formed by *Hampton Poorhouse*, *King's Arbour*, *Hanger Hill Tower*, and *St. Ann's Hill*, making use of the two obtuse angles, as contained within their respective known sides, we have for the mean distance of the points of the acute angles at Hanger Hill Tower and St. Ann's Hill, expressed by a dotted line in the plan of the triangles, 68895.8 feet.

III.	Wardrobe Tower of Windsor Castle - -	— — —	— —	— —	58 9 58.5	
	King's Arbour -	62 40 27.5			62 40 27.5	
	St. Ann's Hill -	59 9 14			59 9 14	
			0.25			
	Windsor Castle from { King's Arbour -				— — —	34819
	{ St. Ann's Hill -				— — —	36032
IV.	Hundred Acres -	53 58 35.75			53 58 30.5	
	Hanger-hill Tower -	63 24 44			68 24 44	
	St. Ann's Hill -	57 36 39.5			57 36 39.5	
		179 59 59.25	1.08	−1.83		
	Hundred Acres from { Hanger Hill Tower				— — —	71932.8
	{ St. Ann's Hill -				— — —	79209.7

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No. of triangles.	Names of the stations.	Observed angles.	Spherical excess.	Diff. or error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	° ′ ″	Feet.
V.	Severndroog Castle, Shooter's Hill -	53 31 10			53 31 9.75	
	Hanger Hill Tower -	55 53 44.3			55 53 44	
	Hundred Acres -	70 35 6.75			70 35 6.25	
		180 0 1.05	1.18	—0.13		
	Severndroog Castle from { Hanger Hill Tower				— — —	84375
	Hundred Acres -				— — —	74076.2
VI.	Norwood - -	107 53 37			107 53 35.75	
	Hanger Hill Tower -	26 12 22.5			26 12 23	
	Severndroog Castle -	45 54 1.5			45 54 1.25	
		180 0 1	0.44	+0.56		
	Norwood from { Hanger Hill Tower				— — —	63672.1
	Severndroog Castle				— — —	39154.4
VII.	Norwood - -	88 5 58			88 5 58.07	
	Hanger Hill Tower -	29 41 20.75			29 41 21	
	Hundred Acres -	— — —			62 12 40.93	
			0.53			
	Norwood from Hundred Acres				— — —	35647.5
VIII.	Transit Room, Greenwich Observatory -	111 56 50			111 56 50	
	Severndroog Castle -	47 48 14			47 48 13	
	Norwood - -	20 14 58			20 14 57	
		180 0 2	0.1	+1.9		
	Greenwich Observatory from { Severndroog Castle				— — —	14610.3
	Norwood - -				— — —	31273.9
IX.	Botley Hill - -	74 37 17.5			74 37 18	
	Hundred Acres -	66 0 56 2			66 0 56	
	Severndroog Castle -	39 21 46.25			39 21 46	
		179 59 59.95	0.78	—0.83		
	Botley Hill from { Hundred Acres -				— — —	48725.8
	Severndroog Castle				— — —	70193.4
X.	Wrotham Hill -	54 25 1			54 25 1.25	
	Botley Hill - -	67 53 11			57 53 10.25	
	Severndroog Castle -	57 41 49			57 41 48 5	
		180 0 1	1.12	—01.2		
	Wrotham Hill from { Botley Hill -				— — —	72951.7
	Severndroog Castle				— — —	79960.6

No. of triangles.	Names of the stations.	Observed angles.	Spherical excess.	Diff. or error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	° ′ ″	Feet.
XI.	Frant - -	50 19 19			50 19 18	
	Botley Hill - -	57 15 11.25			57 15 11	
	Wrotham Hill -	72 25 31.2			72 25 31	
		180 0 1.45	1.3	+0 15		
	Frant from Botley Hill -				— — —	90362.4
	Frant from Wrotham Hill -				— — —	79722
XII.	Hollingborn Hill -	— — —			47 18 59	
	Wrotham Hill -	84 12 24.5			84 12 23.5	
	Frant - -	48 28 37.5			48 28 37.5	
			1.52			
	Hollingborn Hill from Wrotham Hill -				— — —	81195
	Hollingborn Hill from Frant - -				— — —	107895.7
XIII.	Fairlight Down -	48 25 53.5			48 25 55	
	Frant - -	79 23 3			70 23 2	
	Hollingborn Hill -	— — —			52 11 3	
			2.85			
	Fairlight Down from Frant - -				— — —	113926
	Fairlight Down from Hollingborn Hill				— — —	141744.4

Thus far the computations have been made from the base on Hounslow Heath (27404.2 feet). We shall now proceed to the base of verification on Romney Marsh, by the fewest triangles which present themselves; but it may be necessary to premise what follows respecting the *data*.

As that part of the earth's surface to which the operation is confined, has been considered as a plane, it is evident that the mode of correcting the angles for computation must, in some degree, have been arbitrary; and therefore it follows, that in reducing the observed angles to those of plane triangles, each angle may be varied to certain limits; and consequently the opposite sides may be varied to certain limits also; but it is evident, that the means of the extreme results, obtained in this manner, must be very near

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the truth, and perhaps will be considered more accurate than the distances deduced from a single correction of the same angles. Accordingly, if we vary the angles (in reducing them to 180°), from Hounslow Heath, to the XIII. triangle, so as to produce the greatest and least lengths of the opposite sides, we shall have 141746 feet, nearly, for the mean distance of Hollingborn Hill from Fairlight Down; which, however, is only about $1\frac{1}{2}$ feet more than the distance in the XIII. triangle.

The computation may be carried on to the base of verification by means of the three following triangles; and the XXIII. and XXIV.

	Angles observed.	For computation.	
	° ′ ″	° ′ ″	
Hollingborn Hill	48 56 $31\frac{1}{2}$	48 56 31	
Allington Knoll	88 25 43	88 25 42	
Fairlight Down	- -	42 37 47	
Allington Knoll	32 59 $22\frac{1}{2}$	32 59 $22\frac{1}{2}$	
Lydd -	225 42 $0\frac{1}{4}$	125 42 0	
Fairlight Down	- -	21 18 $37\frac{1}{2}$	
Ruckinge	- -	103 18 8	derived from the XXIII and XXIV.
Allington Knoll	- -	57 38 33.4	
Lydd -	-	19 3 18.6	

Those triangles, with 141746 feet (Hollingborn from Fairlight), give 41534.4, for the distance of Lydd from Ruckinge; hence, from the XXIII. triangle, the base of verification is found to be 28533.3 feet: which is about 28 inches short of the measurement.

For the distance of Hollingborn Hill from Fairlight Down, deduced from the measured base on Romney Marsh.—As 28533.3 : 28535.66 (the measured base) : : 141746 : 141758 feet, the distance required: the mean of this, and 141746 is 141752 feet.

From this mean distance, all the sides of the remaining triangles in the principal series are derived. And it has not been thought necessary to alter any of the angles, as originally corrected for computation, because of the trifling variations which would consequently arise in the distances on that account.

We should have computed the distances in the vicinity, and to the eastward of Romney Marsh, from the base of verification only, but there are reasons to suppose that it was not measured so accurately as the other on Hounslow Heath.

No of triangles.	Names of the stations.	Observed angles.	Spherical excess.	Diff. or error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	° ′ ″	Feet.
XIV.	Goudhurst - -	35 26 32.5			35 26 34.5	
	Botley Hill - -	40 4 42			40 4 42	
	Wrotham Hill -	104 28 44			104 28 43.5	
		179 59 58.5	1.35	−2.85		
	Goudhurst from Botley Hill				— — —	121813.5
	Goudhurst from Wrotham Hill				— — —	81000.2
XV.	Goudhurst - -	72 23 32.5			72 23 33.87	
	Frant - -	75 33 16			75 33 13.63	
	Wrotham Hill -	32 3 12.8			32 3 12.5	
		180 0 1.3	0.81	+0.49		
	Goudhurst from Frant -				— — —	44391.2
XVI.	Hollingborn Hill -	63 46 44			63 46 47	
	Wrotham Hill - -	52 9 11.5			52 9 11	
	Goudhurst -	64 4 3.5			64 4 2	
		179 59 59	1.22	−2.22		
	Hollingborn Hill from Goudhurst -				— — —	71298.5
XVII.	Tenterden -	67 7 55			67 7 56.46	
	Goudhurst - -	68 13 21			68 13 19.5	
	Hollingborn Hill -	— — —			44 38 44.04	
			0.85			
	Tenterden from Goudhurst -				— — —	54376.5
	Tenterden from Hollingborn Hill				— — —	71887.5

No. of triangles.	Names of the stations.	Observed angles.	Spherical excess.	Diff. or error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	° ′ ″	Feet.
XVIII.	Fairlight Down -	— — —			35 20 58.42	
	Goudhurst - -	49 39 34			49 39 35.77	
	Tenterden -	94 59 26			94 59 25.81	
			0.91			
	Fairlight Down from { Goudhurst -				— — —	93629.2
	Fairlight Down from { Tenterden -				— — —	71637.2
XIX.	Allington Knoll -	48 24 38			48 24 39	
	Hollingborn Hill -	— — —			40 0 58.96	
	Tenterden -	91 34 23			91 34 22.04	
			10.5			
	Allington Knoll from { Hollingborn Hill				— — —	96039.8
	Allington Knoll from { Tenterden -				— — —	61777.5
XX.	Lydd - -	— — —			63 14 9.82	
	Allington Knoll -	73 0 27.5			73 0 27	
	Tenterden - -	43 45 22			43 45 23.18	
			0.67			
	Lydd from { Allington Knoll				— — —	47850.9
	Lydd from { Tenterden -				— — —	66169.2
XXI.	Fairlight Down -	54 59 18.5			54 59 17.31	
	Lydd - -	— — —			62 27 50.18	
	Tenterden -	62 32 53			62 32 52.51	
			0.99			
	Fairlight Down from Lydd				— — —	71692.2
XXII.	Allington Knoll -	32 59 22.5			32 59 23	
	Lydd - -	125 42 0.25			125 42 0	
	Fairlight Down -	— — —			21 18 37	
			0.33			
	Allington Knoll from Fairlight Down				— — —	106926.2
XXIII.	Lydd - -	43 20 48.25			43 20 48.5	
	Ruckinge -	48 58 49.75			48 58 49.5	
	High Nook near Dymchurch -	87 40 21.75			87 40 22	
		179 59 59.75	0.21	—0.26		
	Lydd from { Ruckinge -				— — —	41535.3
	Lydd from { High Nook				— — —	31363.7

No. of triangles.	Names of the stations.	Observed Angles.	Spherical excess.	Diff. or error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	° ′ ″	Feet.
XXIV.	Allington Knoll -	91 27 20			91 27 19.5	
	Ruckinge -	54 19 17			54 19 18.5	
	High Nook -	34 13 21			34 13 22	
		179 59 58	0.09	—2.09		
	Allington Knoll from { High Nook				— — —	23185.7
	Ruckinge				— — —	16053
XXV.	Folkstone Turnpike -	24 17 6.25			24 17 6 25	
	Allington Knoll -	76 1 54			76 1 53 25	
	High Nook - -	79 41 0.75			79 41 0.5	
		180 0 1	0.29	+0.71		
	Folkstone Turnpike from { Allington Knoll				— — —	55463.6
	High Nook -				— — —	54708
XXVI.	Folkstone Turnpike -	— — —			32 6 56 89	
	Allington Knoll -	109 50 40			109 50 39.35	
	Lydd - -	38 2 24			38 2 23.76	
			0.59			
	Folkstone Turnpike from Lydd				— — —	84662.8
XXVII.	Padlesworth -	108 9 34.5			108 9 34.5	
	High Nook -	— — —			14 48 25.5	
	Folkstone Turnpike -	57 2 0			57 2 0	
			0.16			
	Padlesworth from { High Nook -				— — —	48305.2
	Folkstone Turnpike				— — —	14714 3
XXVIII.	Padlesworth -	105 29 40.5			105 29 40	
	Lydd - -	9 38 29			9 38 29 36	
	Folkstone Turnpike -	— — —			64 51 50.64	
			0. 27			
	Padlesworth from { Lydd -				— — —	79536.1
	Folkstone Turnpike				— — —	14714.3
XXIX.	Padlesworth -	12 16 3			12 16 2.65	
	Lydd - -	154 5 54.75			154 5 54.4	
	Fairlight Down -	— — —			13 38 2 95	
			0.59			
	Padlesworth from Fairlight Down				— — — —	147392

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No. of triangles.	Names of the stations.	Observed angles.	Spherical excess.	Diff. or error.	Angles corrected for calculation.	Distances.
XXX.		° ′ ″	″	″	° ′ ″	Feet.
	Swingfield -	48 38 15			48 38 15	
	Padlesworth -	70 54 5.5			70 54 5.5	
	Folkstone Turnpike -	60 27 39.5			60 27 39.5	
		180 0 0	0.06	−0 06		
	Swingfield from { Padlesworth -				— — —	17056.6
	Folkstone Turnpike				— — —	18525 8
XXXI.	Dover Castle, North Turret -	34 39 26.5			34 39 26.5	
	Swingfield -	75 36 40			75 36 40	
	Folkstone -	69 43 53.5			69 43 53.5	
		180 0 0	0.13	−0.13		
	Dover Castle from { Swingfield -				— — —	30560.4
	Folkstone Turnpike				— — —	31555.7

The two last triangles give 42562.7 feet for the distance of Dover Castle from Padlesworth. The angle at Dover Castle, between Folkstone Turnpike and Padlesworth, was 15° 18′ 44″½ by observation; and that at Padlesworth, between Dover Castle and Folkstone Turnpike, 34° 29′ 42″½.

XXXII.	Dover Castle -	— — —			21 37 55.42	
	Padlesworth -	152 15 25.5			152 15 25.15	
	Fairlight Down -	— — —			6 6 39.43	
			0.69			
	Dover Castle from Fairlight Down				— — —	186119
XXXIII.	Dover Castle -	— — —			87 30 29.58	
	Fairlight Down -	— — —			43 19 58.52	
	Montlambert -	— — —			49 9 31.9	
			7.4			
	Montlambert from { Dover Castle -				— — —	168827
	Fairlight Down				— — —	245786
XXXIV.	Fairlight Down -	— — —			25 33 55 02	
	Dover Castle -	— — —			110 55 29.83	
	Blancnez -	— — —			43 30 35.15	
			4.78			
	Blancnez from { Fairlight Down -				— — —	252505.6
	Dover Castle -				— — —	116660

No. of triangles.	Names of the stations.	Observed angles.	Spherical excess.	Diff. or error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	° ′ ″	Feet.
XXXV.	Dover Castle -	23 25 0.25			23 25 0.25	
	Montlambert -	— — —			36 53 18.11	
	Blancnez - -	— — —			119 41 41.64	
			1.84			
	Blancnez from Montlambert				— — —	77237.7
XXXVI.	Dover Castle -	12 46 33½	—	—	12 46 42	
	N. D. Calais - -	— — —	—	—	47 27 6	
	Blancnez sig. -	— — —	—	—	119 46 12	
	Notre-Dame at Calais from Dover				— — —	137455
XXXVII.	Calais from Dunkirk 123727 feet.					
	N. D. Calais - - - - -				139 17 30	
	Dover Castle } Dunkirk } - - computed {				19 14 12	
					21 28 18	
	Dover Castle from the Tower of Dunkirk -				— — —	244916

The acute angles in the XXXII. triang. result from the other angle and the including sides.

The angles in the XXXIII. and XXXIV. triangles were obtained in the following manner:

	°	′	″
At Dover Castle, the angle between the white lights at Mountlambert, and the lamp at Padlesworth, was observed - - -	109	8	25.5
For computation -	109	8	25
At Fairlight Down, the angle between the white lights at Montlambert, and Blancnez, was observed,	17	46	5
For computation -	17	46	3.5
At Fairlight Down, between the lamp at Lydd and white lights at Blancnez - -	11	2	31
For computation -	18	2	31½
Angles at Fairlight { in the XXIX. triang. -	13	38	2.95
{ in the XXXII. - sub.	6	6	39.43
Angle at Fairlight, between Dover and Lydd	7	31	23.52

		$7°\ 31'\ 23''.52$
Angle at Fairlight, between Lydd and Montlambert ($17°\ 46'\ 3''\frac{1}{2} + 18°\ 2'\ 31''\frac{1}{2}$) -	add,	$35\ 48\ 35$
Angle at Fairlight in the XXXIII. triangle -		$43\ 19\ 58.52$
Angle at Dover, between Padlesworth and Montlambert - - - -		$109\ 8\ 25$
Angle at Dover, in the XXXII. triang.	sub.	$21\ 37\ 55.42$
Angle at Dover in the XXXIII. - -		$87\ 30\ 29.58$

The third angle, or $49°\ 9'\ 31''.9$ at Montlambert, is the supplemental one.

If from the angle at Fairlight, in this triangle, we take $17°46'\ 3''.5$ we have $25°\ 33'\ 55''.02$, the angle at Fairlight in the XXXIV. triangle: and if to $87°\ 30'\ 29''.58$ we add $28°\ 25'\ 0''.25$ (the ang. at Dover in the XXXV. triang.), it gives $110°\ 55'\ 29''.83$, the angle at Dover: that at Blancnez is the supplemental one.

The angle at Dover, in the XXXVI. was obtained thus: a mean of the several observations between the lamp at Blancnez and white lights fired on the gallery of the church of Notre-Dame at Calais, gave $12°\ 46'\ 33''\frac{1}{2}$. Dr. Blagden very carefully determined the position of the point on the gallery, with respect to the axis of the church spire; this corresponded to an angle of $9''$, which added to $12°\ 46'\ 33''\frac{1}{2}$, gives $12°\ 46'\ 42''\frac{1}{2}$. The other angles of this triangle are reduced from those in a plan of the French triangles, communicated by M. Cassini. And the angle at Calais, with the distance of Calais from the Tower of Dunkirk in the XXXVII. triang. are taken from the same paper.

The angles at Montlambert and Blancnez in the XXXV. triang. result from our distances by computation. The French gentlemen, however, very carefully found them by observation, to be

36° 53′ 29″ and 119° 41′ 29″, the common difference is about 12″ which agreement, perhaps, is as near as can be expected, when it is considered, that a variation of six or seven feet, in either of our computed distances of Dover from Blancnez and Montlambert, will produce that difference.

The situation of the station at Montlambert, as determined by the observations made on this side of the Channel, has not however, totally depended on those made at Fairlight and Dover: another observation at Padlesworth has been used by way of check, or verification; this was made in a very favourable state of the air, when the angle between the flagstaff at the station on Dover Castle, and the mast at Montlambert, was 58° 27′ 11″$\frac{1}{2}$, being 1″$\frac{1}{2}$ more than that found by computation.

Dover Castle was the only station on our side to which the French academicians made observations. We therefore shall close this article with the following comparison. The distances on their part, being taken from "*Exposé des Opérations faites en France en* 1787, *pour la jonction des Observatories de Paris et Greenwich; par* M M. Cassini, Méchain, *et* Legendre."

		By the Eng. triang.	By the French triang.	Diff.
Dover from	Montlambert - feet	168827	168806	21
	Blancnez - -	116660	116648	12
	Calais - -	137455	137442	13
Montlambert from Blancnez		77238	77228	10

But if our distances are determined from the base on Hounslow Heath *only*, the differences will be 14, 7, 7, 6, feet, respectively.

Operations at Greenwich Observatory.

58. By means of a scaffold, perfectly similar in principle to that formerly described, but more slight, as being made for the tem-

porary purpose only, the stand of the instrument was raised to the height of thirty-eight feet above the floor of the transit-room of the Observatory. At this elevation all the surrounding objects which we wished to observe (St. Paul's excepted, which is hidden by the camera turret of the great room) could be distinctly seen, and the angles between them and the south meridian mark accurately measured. As that mark is but at a short distance, namely, about 1600 feet from the transit, and consequently $\frac{1}{10}$th of an inch, corresponding to about a second of an angle on the mark; it was therefore very necessary that the centre of the instrument should be brought with great precision over the centre of the axis of the transit-telescope underneath. In this operation, and indeed in every other while at Greenwich, the Astronomer Royal gave us his best assistance. In the first place, the central point of the axis was determined by the intersection of diagonal lines drawn across the square part in the middle. On this square part, when the telescope was in its horizontal position, a bason of quicksilver was placed, having a small cross made of two thin bits of wood fitted to the inside of the bason, and lying very near the surface of the quicksilver, in such a manner as to make the centre of the cross coincide with the intersection on the brass underneath. A small perspective glass being then fixed in a moveable board under the centre of the instrument, this was made to slide at right angles to itself in the direction of the meridian, and that of the axis of the transit, until the centre of the cross coincided with the axis of vision in looking downwards. The board being there fastened, and the perspective removed, the intersection of silk threads stretched across the board, marked very accurately the point corresponding with the centre of the transit, over which the centre of our instrument was brought by the help of the plummet. The second method was still more direct. Dr. Maskelyne had an object glass prepared for his transit telescope, of a focus suited to

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the vertical height of the stand of our instrument above it. This glass being applied to the transit, and the aperture contracted by a piece of pasteboard with a circular hole in the middle, a very small pin-hole being likewise made in the board at top, the same was gradually moved by directions from the observer below, looking through the telescope in its vertical position, until the pin-hole nicely coincided with the axis of vision. The instrument was then brought as before, by the help of the plummet, exactly over the pin-hole. In this manner, which was that adhered to, no doubt remained of more than about $\frac{1}{100}$th part of an inch, with respect to the centre of the instrument being in the intersection of two vertical planes passing through the axis of vision, and that of motion of the transit underneath. After having remained a week, the coincidence of the pin-hole with the axis of vision of the telescope was tried, and found to have suffered no alteration.

Bearings and Distances of the Stations.

59. Let (fig. 2. Pl. XV.) G be Greenwich Observatory; MM its meridian; PP, the perpendicular to the meridian; S, Severndroog Castle; W, Wrotham Hill. Draw SB parallel to the meridian MM; and SA, WM parallel to PP the perpendicular.

		°	′	″
From the angles in the v. triangle to the x. inclusive, (see the plan of the triangles) we get the angle - - -	GSW =	152	28	56
The angle GSB = 16° 10′ 26″ (the complement of AGS) + 90° - - -	sub.	106	10	26
There remains the angle BSW, or the bearing of Wrotham Hill from the parallel SB, south-eastward		46	18	30

The distance GS = 14610.3 (triang. VIII.) with AGS = 73° 49′ 34″ and its complement, give -	AS = 14032 AG = 4070
And the distance SW = 79960.6 (triang. x.) with BSW = 46° 18′ 30″ and its complement, give -	BW = 57817 BS = 55233
Wrotham Hill from Greenwich merid. and its perpendicular	MW = 71849 MG = 59305

In like manner, by drawing parallels through the several stations, all the bearings and distances have been obtained. Those on the western side of the meridian, of course, are derived from the bearing of Norwood.

The direct bearings and distances from Greenwich, are computed with the distances from the meridian and its perpendicular. Thus MW = 71849, and MG = 59305, with the right angle at M, give 50° 27′ 48″, for the bearing; and 93163 feet, the distance of Wrotham Hill.

Table, containing the Bearings of the Stations from the Parallels to the Meridian of Greenwich: also their Distances from the Meridian and its Perpendicular.

Stations.		Bearings.		Distances from Meridian.	Distances from Perpend.
		° ′ ″		Feet.	Feet.
At Greenwich.					
Severndroog Castle	observed	73 49 34	SE	14032	4070
Norwood	observed	38 7 16	SW	19306	24603
At Norwood.					
Hundred Acres - -		42 22 39	SW	43333	50937
Hanger Hill - -		49 31 23	NW	67739	16729
At Hanger Hill.					
Hampton Poorhouse -		23 30 53	SW	83085	18537

Stations.	Bearings.		Distances from Meridian.	Distances from Perpend.
	° ′ ″		Feet.	Feet.
St. Ann's Hill - -	48 34 42	SW	119402	28852
King's Arbour - -	65 33 27	SW	102263	1098
At Severndroog Castle.				
Botley Hill - -	11 23 18	SW	172	72881
Wrotham Hill - -	46 18 30	SE	71849	59305
At Wrotham Hill.				
Frant - - -	6 50 58	SW	62341	138458
Goudhurst - -	25 12 15	SE	106345	132596
Hollingborn Hill - -	77 21 26	SE	151082	77079
At Goudhurst.				
Tenterden - -	72 54 53	SE	158321	148571
Fairlight Down - -	23 15 17	SE	143312	218618
At Tenterden.				
Lydd - - -	50 27 12	SE	209345	190701
Allington Knoll - -	85 47 25	NE	219933	144036
At Allington Knoll.				
Ruckinge - -	70 25 32	SW	204807	149414
High Nook - -	21 1 48	SE	228253	165678
Folkstone Turnpike -	82 56 19	NE	274976	137216
At Folkstone Turnpike.				
Padlesworth - -	64 18 47	NW	261715	130839
Swingfield - -	3 51 8	NE	273730	118734
Dover Castle - -	65 52 46	NE	303775	124322
At Dover Castle.				
Montlambert - -	27 56 55	SE	382910	273458
Blancnez Signal - -	51 21 55	SE	394904	197159
Calais Spire - -	64 8 37	SE	427470	184268
Tower of Dunkirk -	83 22 49	SE	547058	152556

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Dunkirk is 1420 toises = 9080 feet from the meridian of Paris (*Exposé des Opérations*, &c. *en* 1787, p. 66.), which taken from 547058, its distance from that of Greenwich, there remains 537978 feet, the distance of the meridians of Paris and Greenwich on the parallel (to the perpendicular) passing through Dunkirk, being only five feet short of the distance when the inclination of the meridian of Paris to that parallel, is brought into the computation.

Table containing the Bearings and direct Distances of the Stations from Greenwich Observatory.

Stations.	Bearings.	Distances.	Stations.	Bearings.	Distances.
	South-west-ward.	Feet.		Sou'h east-ward.	Feet.
Norwood -	38° 7′ 16″	31274	Goudh. Steeple	38° 43′ 49″	169974
Hundred Acres	40 23 18	66876	Hollingb. Hill	62 58 13	169608
Hanger Hill			Tenterd. Steepl.	46 49 11	217115
Tower -	76 7 39	69774	Fairlight Down	33 14 47	261404
Hampt. Poorh.	77 25 22	85128	Lydd Steeple	47 40 6	283182
St. Ann's Hill	76 24 56	122836	Allington Knoll	56 46 44	262901
King's Arbour	89 25 6	102268	Ruckinge	53 53 16	253517
	South-east-ward.		High Nook	54 1 33	282044
			Folkst. Turn-		
Severndr. Cast.	73 49 34	14610	pike -	63 28 49	307311
Botley Hill -	0 8 7	72881	Padlesworth	63 26 17	292598
Wrotham Hill	50 27 48	93163	Swingfield Stee.	66 33 2	298372
Frant Steeple	24 14 23	151846	Dover Castle	67 44 34	328231

Of the horizontal Angles on a Spheroid.

60. Let C (fig. I. Pl. XV.) be the centre, CP, CE the polar and equatorial semi-axes; PF, PE two given meridians; B, O two points on the meridians having given latitudes. Draw the verti-

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cals BR, OS, or perpendiculars to the meridians, to meet the axis in R and S; from which points draw RH, SK parallel to SO, RB respectively. Let C be the centre of a sphere on which the points *b*, *o*, have the same latitudes and difference of longitude as the points B, O, on the spheroid: draw the radii C*b*, C*o*, and arc *bo*. Then because C*b* is parallel to RB and SK, and C*o* is parallel to SO and RH, the planes C*bo*, RBH, SKO are parallel to each other; and therefore each of the angles BRH, KSO is equal to the angle *b*C*o*, or arc *bo* on the sphere. And since the planes SKO, RBH, C*bo*, are equally inclined to the meridians, the angle KOP on the spheroid will be equal to *bop* on the sphere; and the angle HBP equal to *obp* (supposing those angles to denote the true inclinations of the planes). Hence, the horizontal angle OBP on the spheroid, will exceed *obp* on the sphere, by the angle OBH: and for the like reason, the angle BOP on the spheroid will be less than *bop* on the sphere by the angle BOK. And because the planes BRH, KSO are parallel to each other, a third plane (BRO) intersecting them, will make the alternate angles equal to each other; therefore the excess on one side, is equal to the defect on the other, or the angle OBH equal to BOK; and consequently the sum of the angles PBO, POB on the spheroid, equal to the sum of the angles *pbo*, *pob* on the sphere, supposing those angles to represent the inclinations of the planes.

From B and O draw the tangents BG, BD, OQ to the arcs BH, BO, OK, meeting RH, SO, SK produced; draw GD, which will be in the plane of the horizon of the point B, and also in that of the meridian EP. In like manner, a line from Q meeting a tangent to the arc OB drawn from O, would be in the planes of the horizon of the point O, and the meridian FP; but this line, with some others, are omitted in the figure to prevent confusion.

Since in the present position of the planes, the horizontal angle HBP, or GBP is equal to the angle *obp*; and KOP or QOP is equal

to *bop*, if we conceive the planes GBR, QOS to revolve equably about the verticals BR, OS, it is evident, that in every contemporary position, the sum of the horizontal angles at B and O will be the same, and therefore there are an indefinite number of points in the verticals SD, RB (supposing the latter to be produced upwards) through which the planes may be drawn to make the sum of the horizontal angles on the spheroid *accurately*, the same as the sum of the spherical angles at *b* and *o*. Conceive the plane GBR to move round the vertical RB, till it cuts the vertical SD in D, then the horizontal angle (OBP) on the spheroid will exceed *obp* on the sphere by the angle GBD included between the tangents BG, BD. Now, suppose it to cut the vertical in O at the surface ; through O draw RI to meet the plane of the horizon of the point B in I, then the difference of the horizontal angles in that case, will be the angle GBI (supposing BI to be joined), being greater than the horizontal angle GBD by the angle DBI. Hence, if we suppose an instrument at B which measures angles in the plane of the horizon, and BD its telescope which may be moved in a vertical plane, it is evident that the horizontal angle PBD is diminished as the point (D) in the vertical (OD) to which the observation is made, is elevated : and for the like reason, the horizontal angle (POB) will be augmented when the instrument is at O on the other meridian. This supposes the latitude of the place O to be greater than that of B ; for when the latitudes are the same, the planes of the verticals will coincide, and the horizontal angles will become equal, and the same as on a sphere.

61. To find a point in the vertical RB (produced if necessary) through which the vertical plane at O must pass, to make the difference of the horizontal angles at the point O, the same as a given difference in the horizontal angles at B. Let the angle GBD be the given difference at B ; then if an equal angle be made at O in the plane of that horizon, OQ being one of the containing sides, the

other side will meet the plane of the meridian KP (continued to the horizon of O) in some point, from which if a line be drawn to S, it will cut the vertical RB in the point required: this will be evident by conceiving lines to be drawn in the plane of the meridian BP similar to those in the plane of the other meridian. From hence it will appear, that if the horizontal angles (OBP, BOP) on the spheroid, are taken in the planes of the respective horizons, or the tangents are in horizontal positions, and directed to the verticals, their sum (OBP + BOP) will be *less* than the sum (*obp* + *bop*) on the sphere. If the angles are taken to the verticals at the points O, B, on the surfaces, their sum will be *greater*: but if OD be bisected, and also the like part of the other vertical between B and the plane of the horizon of the point O, and the horizontal angles are taken to those points of bisection, their sum will be equal to the sum of *obp* and *bop*. In the two former cases, however, it will be difficult to determine the difference by computation, because of the minute angles subtended by DI, and the similar line in the plane of the other horizon, except the spheroid be very oblate.

62. From what has been said, it follows, that if the latitudes of two points B, O, and the horizontal angles PBO, POB are given on a spheroid, the third angle BPO cannot be found by spherical computation in the usual manner. But because their sum (PBO + POB) may be considered as equal to the sum (*pbo* + *pob*) on a sphere, the corresponding spherical angles may be found as follows:

Having two sides, and the sum of the opposite angles of a spherical triangle, to find those angles:

As the tangent of half the sum of the sides,
Is to the tangent of half their difference;
So is the tangent of half the sum of the angles,
To the tangent of half their difference.

Or thus. Let s and c represent the *sine* and *cosine* of the sum of the angles; m the *sine* of the greater side, n that of the less; then

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$\frac{\text{[illegible]}}{m \pm nc}$ will be the *tangent* of the less angle. The negative sign taking place when the sum of the angles is above 90°.

The angles (HBP, KOP) for computation being thus found, the angle at P, or the difference of longitude will from thence be determined ; and consequently the value of the arc BO on the spheroid.

63. *Method of computing the horizontal angles.* Let the figure be an ellipsoid whose semi-axes CE, CP are 3496740, and 3477210 fathoms : and suppose the latitudes of the places B, O, are 49° 40′, and 50° respectively ; and their difference of longitude 30′.

The two co-latitudes and the included angle 30′ will give the spherical angles *pbo*, *pob*, 43° 51′ 48″.3 and 135° 45′ 16″.2 respectively; and the arc *bo*, or angle $bCo = 27'49''.7$. Now because the verticals BR, OS are respectively parallel to the radii *b*C, *o*C ; and the tangents BG, OQ parallel to the tangents of the arc *bo* at *b* and *o*, therefore the planes of the horizons of B and O will intersect the verticals RB, SO (produced), and their parallels RG, SQ, in the same angles as the planes of the horizons of *b* and *o* on the sphere would cut the radii C*b*, C*o* produced : these angles may be determined with the *co-tangents*, and *co-secants* of the latitudes, and the *secant* of the arc *bo* to any radius. And hence we get the angle DGB = 44° 14′ 40″.3 and the angle DGR = 89° 40′ 4″; GD being the intersection of the plane of the horizon of B and the plane of the meridian EP. And the angles at Q in the plane of the other meridian, will be 43° 51′ 44″.7, and 89° 59′ 56″.

Let *a* denote the *sine* of an arc whose *tang.* is $\frac{CE}{CP} \times$ *co-tang.* 49° 40′ (the *lat.* of B), then $\frac{a \times CE}{\text{co-sin. } 49^\circ\, 40'} = 3508112$ fath. the vertical BR. In like manner, the vertical OS = 3508225 fath. Hence, from the nature of the ellipse, we get RS the distance of the verticals in the axis = 148 fath. Draw RW parallel to GD, then we have the angle SWR = 90° 19′ 56″ the supplement of DGR ; and the angle WSR being 40° (the *co-lat.* of the point O), we get RW,

or $GD = 95.13$ fath. In the same manner, if RL be drawn parallel to the intersection of the planes of the other meridian and horizon, its length will be 95.79 fath. Now the angles BRG, OSQ being each $27' \, 49''.7$ (the angle bCo), the tangents BG, OQ to the radii BR, OS, will be $BG = 28398.5$, and $OQ = 28399.5$. Hence BG, and GD with $44° \, 14' \, 40''.3$, the included angle at G, will give the angle $GBD = 8' \, 3''\frac{1}{4}$, the difference of the horizontal angles on the sphere and spheroid at B. And the angle at O (with OQ and RL, and $43° \, 51' \, 44''.7$ the included angle at Q), will be found the same, or $8' \, 3''\frac{1}{4}$. Therefore the horizontal angles on the spheroid will be $PBO = 43° \, 51' \, 48''.3 + 8' \, 3''\frac{1}{4}$; and $POB = 135° \, 45' \, 16''.2 - 8' \, 3''\frac{1}{4}$. Those angles are computed on a supposition that the tangents BG, OQ are horizontal; but no sensible variation would arise if they were directed to the verticals at the surfaces O and B, for the vertical SO, and the distance SR with the included angle at $S = 40°$, will give the angle SOR (DOI) not more than 5 or $6''$; and therefore, was the point D a mile above the surface, the length of DI which subtends the variation in the horizontal angle at B, would be less than 3 inches.

64. The application is only the reverse of what is given above. For suppose the latitudes of two places B,O on a spheroid are $49° \, 40'$ and $50°$, and the observed horizontal angles OBP, POB to be $43° \, 59' \, 51''.55$ and $135° \, 37' \, 12''.95$; to find the difference of longitude;

The sum of the observed angles being $179° \, 37' \, 4''.5$, we get (62.) $45° \, 56' \, 45''$ for half the difference of the spherical angles; therefore $KOP = 135° \, 45' \, 17''\frac{1}{4}$, and $HBP = 43° \, 51' \, 47''\frac{1}{4}$ are the angles for computation: hence the angle OPB, or difference of longitude $=$ $30'$, and the opposite side $BO = 27' \, 49''.7$.

65. If we determine the side OP, with the observed angle OBP, and the two including sides, it will be found $= 40° \, 0' \, 5''.6$, which exceeds the truth by $5''.6$; but it will fall short when that angle is greater than BOP: this excess (or defect) is the arc HO which subtends the difference in the horizontal angles on the sphere and

spheroid, which arc, in the present case, is 5″.6 (the difference in the horizontal angles being 8′ 4″.3). Therefore as the angles at B and O approach to equality, the computed results with the observed angles become nearer the truth: and hence it follows, that when the observed angle OBP is a right one, and the arc BO is not of great extent, the spherical computations will give the latitude and longitude of the point O without sensible error.

66. But when the latitude of the place (B) is given, together with the observed angle (OBP) between the meridian (BP) and a given arc (BO), proceed thus for the latitude of the place O, and the difference of longitude. Suppose PSD (fig. 3. Pl. XV.) to be the observed angle, SP the co-latitude, and SD the given arc on a spheroid. With the two sides and included angle as a spherical triangle, compute the angle PDS, which will always be nearly the same as would be found by observation; then make the angle SDA (which will fall on the lower side of SD, if PD is greater than PS), equal to half the difference of the angles PSD, PDS: now, if we consider the triangle SDA as a plane one, the angles PAD, PDA will be equal, and SA will be the difference of latitude of the points S, D, which being found with the given length of SD (allowing for the curvature of the sides), we have the latitude of the point D: then with the three given sides of the triangle PDS, find the angle SPD by spherical computation, which will be the difference of longitude.

Distance of the Parallels of Latitude of Paris and Greenwich.

67. Suppose (fig. 3. Pl. XV.) PS, PD to be the meridians of Greenwich and Dunkirk; G Greenwich Observatory; D the Tower of Dunkirk; GE the perpendicular to the meridian at Greenwich; RD, RG the distances of Dunkirk from the meridian of Greenwich, and its perpendicular, or 547058, and 152556 feet (59); DS the vertical or great circle passing through D, and making the angle at S a right one.

The perpendicular DS to the meridian at S, will fall below R about 52 feet. It is found thus: assume DR, or DS = 1° 29′ 25″, which will be its value nearly (for great accuracy is not necessary in this case): then, as *cosin.* DS : *rad.* : : RG (152556 feet,) : 152608 feet, or 25435 fath. = GS.

Now in the right angled triangle PSD, it follows (65.) that the side PD, computed spherically with the other two sides, will always fall short of the truth by a quantity determinable from the nature of the spheroid; which in the present case (supposing the earth an ellipsoid, and the degrees on the meridian, and perpendicular at S, to be 60863, and 61184 fath.) will be 0″.3 nearly: therefore, if the latitude of the point D be given, and that of S is to be computed from DP and the other *data*, it will be necessary to diminish DP by that quantity (0″.3). According to the latest observations, the latitude of the Tower of Dunkirk is 51° 2′ 11″.4 (*Conn. des Tems*, 1797-98, p. 372), therefore PD = 38° 57′ 48″.6, from which take 0″.3, and we have 38° 57′ 48″.3 for computation. Hence, as *cosin.* 1° 29′ 25″ (SD) : *rad.* : : *cosin.* 38° 57′ 48″.3 : *cosin.* 38° 56′ 22″ = SP; consequently, GS = 38° 56′ 22″ − 38° 31′ 20″ = 25′ 2″. And if DA be the parallel of latitude of Dunkirk, DP — SP = 38° 57′ 48″.6 − 38° 56′ 22″ = 1′ 26″.6. Now, GS being 25435 fath. (answering to an arc of 25′ 2″) we have 25′ 2″ : 25435 : : 1′ 26″.6 : 1466½ fath. = SA, which added to SG gives 26901½ fath. the length of the arc of latitude between Greenwich and Dunkirk. In pag. 69, "*Exposé des Opérations, &c. en* 1787", we have 125505.92 toises * = 133757.9 fath. the distance of the parallels of lat. of Paris and Dunkirk; the sum of this, and 26901½, is 160659 fath. the distance of the parallels of latitude of Paris and Greenwich. Now, if the latitude of the Observatory at Paris is 48° 50′ 14″, the

* The length of the French toise, is to that of the English fathom, as 4263 to 4000. *Philos. Trans. Vol.* LVIII. p. 326.

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difference of latitude between Paris and Greenwich will be 2° 38′ 26″, hence 2° 38′ 26″ : 160659 : : 1° : 60843 fath. the length of the degree on the meridian in latitude 50° 10′ (the middle latitude nearly, between Paris and Greenwich), which differs but little from M. Bouguer's hypothesis (Philos. Trans. 1787); and exceeds M. Lalande's on the ellipsoid about 7 fathoms (*Astron. Art.* 2711.) But if the lat. of Paris be 48° 50′ 15″ (*Conn. des Tems*, 1797-98, p 373.) we get the degree = 60849 fath.

There is, however, an inconsistency in the foregoing results, not easily accounted for without supposing the latitude of Greenwich, or that of Dunkirk, or Paris, to be erroneous. The distance of the parallels of latitude of Greenwich and Dunkirk is $26901\frac{1}{2}$ fath. answering to 26′ 28″.6, the difference of latitude; whence we get 60962 fath. for the degree in lat. 51° $15'\frac{1}{2}$ (the middle lat. between Greenwich and Dunkirk, nearly). And the length of the meridional arc between Paris and Dunkirk is, 133758 fath. corresponding to the difference of lat. 2° 11′ 56″.4, these give but 60827 fath. for the degree in la49° 57′; the difference is 135 fath. which is about 100 fath. greater than the increase from lat. 49° 57′ to 51° $15''\frac{1}{2}$ on any of the spheroids hitherto assumed for the figure of the earth. Some small errors may have arisen from our method of reducing the observed angles to those for computation; but the final results could only be varied a few feet on that account. But even supposing an error of 4 fath. or 24 feet, on our part, in the distance of Dunkirk from the perpendicular, it will not amount to $0''\frac{1}{4}$ of latitude.

Nor is the length of the meridional arc materially affected by any probable value of the perpendicular DS; or a small variation in the latitude of Dunkirk. For suppose its latitude to be 51° 2′ 9″.3 (as determined by M. La Caille), and the arc DS = 1° 29′ 35″: then proceeding as above, we get SA = 1470.7 fath. which exceeds the former length about $4\frac{1}{2}$ fath. But the degree in latitude 51°

$15'\frac{1}{2}$ is 60892 fath. And (taking the lat. of Paris $48° 50' 15''$) that in $49° 57'$ will be 60843; therefore in this case, the difference in the degrees is but 49 fath. instead of 135.

But the difference in the two values of the arc of latitude GS will evidently be the same (very nearly), as the difference in the latitudes of the point D: for let DP be $38° 57' 48''.3$ and $38° 57' 50''.4$ and the arc $SD = 1° 29' 25''$ as before; then $PS = 38° 56' 22''$ and $38° 56' 24''.1$, the difference being $2''.1$ (the same as that in the latitudes of D); and the two values of the arc GS are $25' 2''$ and $25' 4''.1$; therefore the length of the arc GS being 25435 fath. we have 60963, and 60878 fath. for the meridional degrees in lat $51° 16'$.

From hence it appears, that if the latitudes of Paris, Dunkirk, and Greenwich, are $48° 50' 15''$, $51° 2' 11''.4$, and $51° 28' 40''$ respectively, the difference in the meridional degrees in latitudes $49° 57'$ and $51° 16'$ is about 135 fath.; which will not accord with any of the received hypotheses.

The latitude of the tower of Dunkirk was deduced by M. Delambre from that of the place where he made his observations. He took the altitudes of the pole-star with the *circle of repetition* * (about 1 foot in diameter), and determined his latitude from 300 observations, differing, as we are told, somewhat less than $1''\frac{1}{2}$ of a degree. This instrument is now in general use with the French astronomers. But though their method of determining the meridional altitude of a star is extremely ingenious, yet those celebrated mathematicians may rely too much on the instrument itself, in an operation which requires the greatest nicety. For it is the opinion of the first artist in England, who has examined its construction, as far as it can be done from the description and engraving, that it is wholly a matter of chance if the plane of the circle be

* For the description see *Conn. des Tems*, 1797–98.

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vertical when it is adjusted for observation; and therefore, if the same mode of adjustment is constantly adhered to, the results may be consistent, but finally erroneous. The same ingenious artist, however, intends to publish his remarks on the construction of this instrument, with the description of another of his own invention for the same purpose, but less liable to objection.

Directions of the Meridians at Goudhurst and Botley Hill. And Length of a Degree perpendicular to the Meridian.

68. A small table had been previously computed of the times when the pole-star was at its greatest apparent elongations from the meridian. On these occasions the Board of Longitude's *premium watch*, by the late Mr. Harrison, was made use of. Its rate of going all the time that it was in the field in 1787, was very uniformly $9\frac{1}{2}$ seconds a day faster than mean time. But in the winter months the watch gradually changed its rate from *plus* to *minus;* and when it was carried into the field in 1788, and, during the five weeks that it continued there, it regularly lost on mean time from $3\frac{1}{2}$ to 4 seconds each day; having in that short interim been twice compared in Argyll-street, with an excellent clock made by Cumming, with an improved Ellicott's pendulum.

Let B (fig. 4. Pl. XV.) be Botley Hill; PBR its meridian, O Greenwich Observatory (which is nearly on the meridian of Botley Hill); G Goudhurst; W Wrotham Hill; T Tenterden; GR an arc of a great circle, making the angle at R a right one; also let * * represent the circle of the pole-star's apparent declination; and B*, G* be two azimuth circles touching that circle.

Aug. 14, 1788, at Goudhurst, the angle * GT, or that between the pole-star when at its greatest apparent distance from the

	°	′	″
meridian on the east side, and the lamp at Tenterden was observed. - - - -	104	32	19½
The angle BGT between the lamps at Botley Hill and Tenterden was repeatedly observed - -	167	43	56
Angle * GB - - - - - - diff.	63	11	36½

Aug. 23, 1788, at Botley Hill, the angle * BW, or that between the pole-star at its greatest apparent elongation, and the lamp at Wrotham Hill, was observed † - - - - - - - -	76	21	37
The angle WBG by repeated observations was	40	4	42
Angle * BG - - - - - - sum	116	26	19

To obtain the star's azimuths at B and G it will not be necessary to have the latitudes very correct. We therefore may take the values of the meridional arcs from M. Bouguer's hypothesis, which agrees nearly with the measurement in these latitudes. And as Botley Hill is but 172 feet from the meridian of Greenwich, OB will be 72881 feet (59.), the distance from the perpendicular, without sensible error.

The latitude of the middle point between B and O (Botley Hill and Greenwich) is about 51° 23′: the degree in this latitude is

† The observations of the pole-star at Goudhurst and Botley Hill, were repeated for several nights at each place, but those here given are the most exact. At Goudhurst the angle which the star made with the lamp being noted, the telescope removed, and the plane of the instrument being turned 180°, or half round; the telescope replaced and directed again to the star, the difference on the circle was found to be only 1″¼. And at Botley Hill the difference between the readings was no more than 1″½.

At Folkstone Turnpike by means of the star's double azimuth, we obtained the direction of the meridian with High Nook 120° 24′ 57″.87. And with Fairlight Down 120° 47′ 45″.87. But nothing conclusive was deduced from those angles for want of reciprocal observations.

= 60844 fath. (Bouguer, *Fig. de la Terre*, p. 305. or Philos. Trans. 1787); hence the arc OB = 72881 feet, will be 11′ 59″, which added to OP, the co-lat. of Greenwich, gives 38° 48′ 19″ = BP: now in the right angled spherical triangle P * B we have PB = 38° 43′ 19″, and P * = 1° 49′ 22″.8, the star's apparent polar distance nearly on Aug. 23; hence the angle PB *, or azimuth, = 2° 54′ 54″.1, which added to the angle * BG gives 119° 21′ 13″.1, the angle PBG.

In the right angled triangle BRG, we have BG = 121813½ feet (triang. XIV.) and the angle RBG = 60° 38′ 47″ the supplement of PBG, whence RG = 106174, and RB = 59713 feet: the value of the latter on the meridian will be 9′ 48″.7 nearly; and that of RG (from a few trials) is about 17′ 20″. Hence 38° 43′ 19″ + 9′ 48″.7 = 38° 53′ 7″.7 = RP, which, with 17′ 20″ (RG), and the included right angle, will give GP = 38° 53′ 11″. The star's apparent distance from the pole on Aug. 14, was 1° 49′ 25″.3 nearly †; hence the star's azimuth, or angle PG * = 2° 54′ 20″.7 which taken from the angle BG *, there remains 60° 17′ 15″.8 = BGP.

It is evident that a considerable variation in the value of the arc RG produces but a small one in that of the latitude of the point G, which, in the present case, principally depends on the value of the arc RB, or of RO; we therefore will suppose GP = 38° 53′ 11″, as found by the computation above. Then in the spheroidical triangle BPG we have the sides PB, PG, with the angles at B, G; whence (62.) we get 60° 7′ 38″ and 119° 30′ 50″.9, the angles for computation at G and B (the difference of the horizontal angles on the sphere and spheroid, in this case, being 9′ 37″.8): from these angles and their opposite sides, the difference of longitude BPG will be found 27′ 36″.74; and the arc BG 19′ 55″.13. Therefore

† In 1786, the Astronomer Royal very accurately determined the declination of the pole-star, whence the mean polar distance at the beginning of that year was 1° 50′ 8″.35. The mean annual precession in declination being 19″.55.

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as $19' 55''.13 : 121813\frac{1}{2}$ feet (BG) : : $1° : 61155$ fath. the length of a degree on the spheroid in the direction BG, and in lat. $51° 11'\frac{1}{2}$, the lat. of the middle point between B and G. And as *rad.* : *sin.* PG : : *sin.* RPG : *sin.* $17' 20''.06$ = RG the perpendicular arc = 106174 feet ; whence the degree in the latitude of the point R = 61251 fath. nearly.

In the foregoing computations the values of the meridional arcs are nearly the same as the values, which may be inferred from the measured arc between Greenwich and Paris, supposing the latitude of the latter to be $48° 50' 14''$. Small errors, however, in the values of the arcs OB, BR, are of little consequence, because that of the oblique arc BG, and also of the perpendicular one RG principally depend on the horizontal angles at B and G, for a small variation in either angle will make a considerable one in the degrees derived from those arcs when, as in the present instance, they are small. For that reason, in the following table, we have adopted the perpendicular degree, as determined by the operation in 1793, on a distance of 64 miles, which therefore is probably much more correct than the above.

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Table of the meridional and perpendicular Degrees from Lat. 50° to 52°.

Lat.	Deg. on Merid.	Deg. perp. Meri.
° ′	fath.	fath.
50 0	60839	61177
10	60843	61178
20	60846	61180
30	60850	61181
40	60853	61182
50	60856	61183
51 0	60860	61184
10	60863	61186
20	60867	61187
30	60871	61188
40	60874	61189
50	60877	61190
52 0	60881	61191

This table is computed on an ellipsoid derived from 60843 fath. the meridional degree in lat. 50° 10′ (67.), and 61182 fath. the perpendicular degree in lat. 50° 40′.

Of the Longitudes of Dunkirk and Paris from Greenwich.

69. Let (fig. 3. Pl XV.) PS, PD be the meridians of Greenwich and Dunkirk; G Greenwich Observatory, D the Tower of Dunkirk; and DS the perpendicular to the meridian at S, as in Art. 67. Then GS = 25435 fath. and SD = 91176 fath.

From the table in the last Article we get the arc GS = 25′ 4″.4; therefore PS = 38° 56′ 24″.4; then from the same table, the perpendicular degree in the lat. of S is = 61185 fath.; consequently the arc SD = 1° 29′ 24″.6 nearly; or 1° 29′ 24″.7, allowing for the variation in the curvature. Now those sides, with the included right

angle at S, give $2^\circ\ 22'\ 13''$, the angle at P, or difference of longitude; and $38^\circ\ 57'\ 50''.7 =$ DP, or $51^\circ\ 2'\ 9''.3$, the computed latitude of Dunkirk. This latitude is in excess (65.), the correction, however, may be found as directed in Art. 66.; but the more exact method is to determine what would subtend the difference in the horizontal angles on the sphere and spheroid at the points S and D (63.), which will be about 34 feet, answering to $0''.3$ nearly (67.): this taken from $51^\circ\ 2'\ 9''.3$ leaves $51^\circ\ 2'\ 9''$, the latitude of D.

The longitude of the Tower of Dunkirk being $2'\ 22''$ east of Paris (*Mém. de l'Acad.* 1788), we have $2^\circ\ 19'\ 51''$, or $9^m\ 19^s.4$, the difference of meridians of Greenwich and Paris.

Was the earth an ellipsoid, whose axes are as 230 to 229, the longitude of Paris, from the above measurements, would be $9^m\ 20^s$ nearly (Philos. Trans. 1791): but M. Lalande, in a Memoir on the difference of meridians of Greenwich and Paris (*Conn. des Tems*, 1797-98) objects to this, and contends that the longitude is $9^m\ 21^s$. First, because it agrees nearly with a supposition made by the late Gen. Roy (Philos. Trans. 1787, p. 194). Secondly, because among 61 longitudes, deduced from the eclipses of Jupiter's first satellite, some are found to differ but a few seconds from $9^m\ 21^s$. Thirdly, M. Legendre finds $9^m\ 21^s$ by computation on a spheroid (*Mém. de l'Acad.* 1788).

Gen. Roy's words are, "the difference of longitude between the "two Observatories, as far as can be judged from the map of "Kent, corrected for the error in the direction of its meridian, "amounts to about $2^\circ\ 20'\ 20''$:" this authority is evidently too vague to merit attention. And with respect to the results from Jupiter's satellite (Philos. Trans. 1787), they vary from 9^m to 10^m, and therefore afford nothing conclusive. M. Lalande, however, should have stated the deductions of MM. Sejour and Mechain, from the solar eclipse in 1769, and the occultations in 1786, where

the limits are $9^m\ 18^s$ and $9^m\ 20^s$ (see Dr. Maskelyne's Paper, Philos. Trans. 1787); and he might have added that of Professor Piazzi, who found $9^m\ 19^s.3$ from the sun's eclipse in June, 1788, (Philos. Trans. 1789.)

Taking the longitude of Paris $2°\ 20'\ 15''$, according to M. Legendre, the angle SPD is $2°\ 22'\ 37''$, whence the arc SD = $1°\ 29'\ 40''$, which gives 61011 fath. for the perpendicular degree in lat. $51°\ 4'$, agreeing nearly with M. Lalande, who has given a table of the degrees of latitude and longitude on a spheroid whose axes are as 300 to 299; Astron. edit. 3, Art. 2711. Therefore the length of the perpendicular degree, according to those gentlemen's hypothesis, is about 170 fath. shorter than that deduced from our measurement.

M. Lalande says, "it is now known that the earth is not an "homogeneous spheroid:" this perhaps will not be disputed; but it is also as well known, that the experiments with pendulums, like the different measurements, have not been consistent, nor accurate enough, to afford satisfactory conclusions respecting the ratio of the earth's axes, notwithstanding the computations have lately been made by the first mathematicians, on a supposition that the earth is an heterogeneous ellipsoid. But if the earth be not homogeneous, it may, or it may not be an ellipsoid. The different measurements, however, seem to prove that it cannot be an ellipsoid of any kind.

Nor do we infer from the table (68.) that the earth is an ellipsoid, but some figure upon which the lengths of the degrees on the meridian, and at right angles to it in lat. $50°\ 40'$, are 60853 and 61182 fath. nearly: this granted, the values of the other degrees in the table, though computed on an ellipsoid, cannot be wide of the truth.

In M. Lalande's table the meridional degrees in latitudes

39° 12′ and 23° 28′, exceed the measurements * by 92 and 118 fath. respectively. At the polar circle, however, his hypothesis falls 207 fath. short. But in his memoir we find an article respecting that celebrated operation, in substance as follows: " They write " me from Sweden, that M. Mallet, professor of mathematics at " Upsal, having been at Pello in 1769, to observe the transit of " Venus, examined the stations which had served for the mea-" surement of a degree, and found that country full of high moun-" tains, the attraction of which might influence the direction of " gravity, and consequently affect the length of the degree. His " discussion on the different measured degrees is to be found in " the first volume of the Physical Description of the World, pub-" lished at Upsal in 1772.

" We may add, that the angles of the triangles have not the " precision which we might have hoped for; there is 29″.4 of " difference upon the three angles of the first triangle; (Mauper-" tuis, *Fig. de la Terre*, p. 88.): those angles are altered in the ap-" plication differently from what is warranted by the observations.

" CTK, p. 80,	- 24° 22′ 58″.8	and p. 90,	24° 22′ 54″.3
" HAC, p. 82,	- 112 21 48.6	-	112 21 32.9
" KHN, p. 81 and 82,	143 6 19	-	143 6 3.2"

It has also been conjectured, that the degree in Peru is considerably too long, in consequence of the lateral attraction of the high lands where the measurement was performed (Philos. Trans. 1768). But the results at the polar circle and equator are of very little consequence in settling the point in question; because the distance between the meridians of Greenwich and Paris, and also the perpendicular degree, having been measured in nearly the

* The former by Mess. Mason and Dixon in America, and the latter by Mr. Burrow in Bengal. See a short account of Mr. Burrow's operation, sold by Elmsly and Bremner, Strand, London.

same latitude, the longitude cannot be said to depend on any hypothesis; for a considerable variation in the length of the meridional degree will but little affect that of the perpendicular one. And therefore the difference of meridians obtained from the measurement is a proof that the deductions of Mess. Sejour, Mechain, and Piazzi are true to a second in time; and that $9^m\ 21^s$ resulting from an hypothesis, is more than that quantity too great.

70. *Table containing the Latitude of the Stations; and their Longitudes from Greenwich.*

	Lat.	Long.	In time.
	° ′ ″	West. ° ′ ″	m. s.
Greenwich Ob. -	51 28 40		
Norwood - -	51 24 37½	0 5 3	0 20.2
Hundred Acres - -	51 20 17½	0 11 20	0 45.3
Hanger Hill Tower -	51 31 23½	0 17 48	1 11.2
Hampton Poorhouse -	51 25 35½	0 21 47	1 27.1
King's Arbour - -	51 28 47½	0 26 50	1 47.3
St. Ann's Hill - -	51 23 51½	0 31 17	2 5.1
		East.	
Botley Hill - -	51 16 41½	0 0 3	0 0.2
Severndr. Castle on Shooter's Hill	51 28 0	0 3 41	0 14.7
Frant Steeple - -	51 5 54	0 16 13	1 4.9
Wrotham Hill - -	51 18 54	0 18 47	1 15.1
Goudhurst Steeple -	51 6 49½	0 27 40	1 50.7
Fairlight Down -	51 52 39	0 37 7	2 28.5
Hollingborn Hill - -	51 15 53½	0 39 28	2 37.9
Tenterden Steeple - -	51 4 8	0 41 11	2 44.8
Ruckinge - -	51 3 55	0 53 16	2 33.1
Lydd Steeple - -	50 57 7½	0 54 19	3 37.3
Allington Knoll -	51 4 46	0 57 13	3 48.9
High Nook, near Dymchurch	51 1 11½	0 59 18	3 57.2
Padlesworth - -	51 6 50½	1 8 8	4 32.5

	Lat.			Long.			In time.	
				East.				
	°	′	″	°	′	″	m.	s.
Swingfield Steeple - -	51	8	48	1	11	18	4	45.2
Folkstone Turnpike -	51	5	$45\frac{1}{2}$	1	11	33	4	46.2
Dover Cast. N. turret of the Keep	51	7	$47\frac{1}{2}$	1	19	7	5	16.5
On the Coast of France.								
Montlambert near Boulogne	50	43	2	1	38	51	6	35.2
Blancnez - - -	50	55	$31\frac{1}{2}$	1	42	24	6	49.6
N. D. at Calais - -	50	57	$30\frac{1}{2}$	1	50	56	7	23.7

The method of computation given in Art. 69. is sufficient to show how all the latitudes and longitudes have been obtained: only it has not been thought necessary to apply any corrections, as in that example, three or four of the most distant places excepted. The latitudes are to the nearest $\frac{1}{2}$ second; and the longitudes to the nearest second.

Relative Heights, and terrestrial Refractions.

71. Before we proceed to give any account of the observed angles of elevation or depression, at the stations reciprocally, for trying the quantity of terrestrial refraction, it may be proper to call to remembrance, that, in the measurement of the base on Hounslow Heath, the mouth of the pipe at Hampton Poorhouse was shewn to be elevated about 60 feet above low-water spring-tides at the sea, as far as could then be determined, by referring it to the surface of high water at Isleworth; and that the extremity of the base near King's Arbour, was found, by levelling, to be higher than the former end by $31\frac{1}{4}$ feet.

The mouth of the pipe at the south-east end of the base of verification at High Nook near Dymchurch, in Romney Marsh,

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Lieut. Fiddes found, by levelling, to be above low-water mark, at spring tides, 22.1 feet.

The top of the parapet of the north turret of the Keep of Dover Castle was found by Lieut. Hay, of the Royal Engineers (by levelling from the top of the cliff, at Queen Elizabeth's gun, downwards, and adding to that the height of the ground and Castle above the said gun), to be 465.8 feet above low-water at spring tides. Having also measured a base for the purpose, he determined the height of the cliff geometrically, which agreed within less than a foot of the result by levelling.

In 1773, the height of the floor of the upper story of the Bull Inn at Shooter's Hill, was found, by levelling, to be 444 feet above the Gun Wharf in Woolwich Warren. Since that time the top of the parapet of Severndroog Castle, has been found to be $13\frac{1}{2}$ feet higher than the floor at the Inn. And allowing 22 feet for the height of the Wharf at Woolwich, above low-water at the Nore, the top of Severndroog Castle will be $479\frac{1}{2}$ feet above low-water spring tides.

Lastly, the altitudes of all the intermediate stations have been established by the reciprocal angles of elevation or depression,* gradually carried on from station to station, throughout the whole series of triangles; and no greater uncertainty has been found at Hampton Poorhouse than a few feet, occasioned, no doubt, by the

* Dr. Maskelyne remarks, that it would be of use to have a person to note the thermometer at the object, as well as at the station of the observer, whereby the refraction might be more accurately computed by the application of a new correction. Thus, calling $r = \frac{4}{10} = \frac{1}{10}$th of the arc of distance; $b =$ the height of the uniform atmosphere; $t =$ the difference of the thermometers at the two stations; $x =$ the difference of altitude of the two stations above a common level; the correction would then be $= \frac{rth}{400x}$; and the true or whole refraction would be $= r \mp \frac{rth}{400x}$, according as the thermometer stood lower or higher at the upper station.

uncertainty of terrestrial refraction: for it is to be remarked, that, to the westward of Greenwich, no double, but only single, observations were obtained; wherefore the relative heights of these stations have been determined by taking $\frac{1}{10}$ of the arc of distance for the effect of terrestrial refraction.

72. Suppose C (fig. 5. Pl. XV.) to be the centre of the earth; A and B two stations above the surface SS; AD, BO the horizontal lines at right angles to OC, DC; also, suppose A and B to be the *true* places of the points reciprocally observed, and *a* and *b* their *apparent* ones:

In the quadrilateral AEBC, the angles at A and B are right ones, therefore the sum of the angles EAB, EBA, is equal to the angle at C, or the arc SS contained between the stations: in other words, the sum of the reciprocal depressions (DAB + OBA) below the horizontal lines AD, BO, would be equal to the contained arc, if there was no refraction. But *a* and *b* being the apparent places of the objects at A and B, the angles of depression will be D*Ab*, OB*a*; therefore their sum taken from the angle C, or the contained arc, will leave the sum of the angles *b*AB, *a*BA, or the sum of the two refractions; hence, if we suppose half that sum to be the mean refraction, we have the following rule, when the objects are reciprocally depressed: *subtract the sum of the two depressions from the contained arc, and half the remainder is the mean refraction.*

If one of the objects (B) instead of being depressed, is elevated, suppose to the point G, the angle of elevation being GAD; then the sum of the angles *e*AB + *e*BA will be greater than the sum EAB + EBA (the angle C, or contained arc SS) by the angle of elevation *e*AD; but if from *e*AB + *e*BA we take the depression OB*a* there will remain *e*AB + *a*BA the sum of the two refractions: therefore, the rule for the mean refraction in this case is:

subtract the depression from the sum of the contained arc and elevation, and half the remainder is the mean refraction.

Previously, however, each observation must be reduced to the place of the axis of the instrument, as in the two following examples.

1. At Allington Knoll, the top of the staff on Tenterden Steeple was depressed 3′ 51″ by observation; and the top of the staff was 3.1 feet higher than the axis of the instrument when it was at that station: now the distance of the stations being 61777 feet, we shall find that 3.1 feet will, at that distance, subtend an angle of 10″.4, which added to 3′ 51″, gives 4′ 1″.4 for what the place of the axis at Tenterden would have been depressed, had it been observed instead of the top of the staff.

On Tenterden Steeple the ground at Allington Knoll was depressed 3′ 35″: but the axis of the instrument, when at Allington Knoll, was $5\frac{1}{2}$ feet above the ground, which will subtend an angle of 18″.4, this taken from 3′ 35″, leaves 3′ 16″.6 for what the place of the axis at Allington Knoll would have been depressed.

Contained arc (61777 feet) - -		10′ 6″ nearly.
Sum of depressions 4′ 1″.4 + 3′ 16″.6	sub.	7 18
		2 48
Mean refraction - - -		1 24

or about $\frac{1}{7}$ of the contained arc.

For the relative heights. The mean refraction added to the depression of the axis at Allington Knoll is 1′ 24″ + 3′ 16″.6 = 4′ 40″.6, being 22″.4 less than half the contained arc, and therefore the place of the axis at Allington Knoll is higher than its place when on Tenterden Steeple, by what that difference, or the angle 22″.4 subtends, which will be found = 6.7 feet; this

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taken from 329 feet, the vertical height of the axis at Allington Knoll, leaves 322.3 feet, its height when on Tenterden Steeple.

2. At Allington Knoll the ground at High Nook was depressed - - - - - 46′ 43″

At High Nook the ground at Allington Knoll was elevated - - - - - - 42 34

The height of the axis above the ground at each of those stations was $5\frac{1}{2}$ feet, which, with 23186 feet, the distance between the stations, will give 49″ nearly, the angle subtended by the height of the axis above the ground.

		′ ″
Ground at High Nook - -	depr.	46 43
	sub.	0 49
Place of the axis - -	depr.	45 54
Ground at Allington Knoll -	elev.	42 34
	add,	0 49
Place of the axis - -	elev.	43 23
Contained arc (23186 feet) -	-	3 48.4 nearly.
Sum of contained arc and elevation	-	47 11.4
Depression - - -	sub.	45 54
	diff.	1 17.4
Mean refraction - -	half	0 38.7

or $\frac{1}{6}$ of the contained arc.

Subtract the mean refraction from 43′ 23″ and there remains 42′ 44″.3 for the elevation of the place of the axis at Allington Knoll corrected for refraction, which, with the distance of the stations, give 301.7 feet, for the height of Allington Knoll above High Nook: this being added to 27.6 feet, the height of the

axis at High Nook above low-water, and we have 329 feet, the height of the axis at Allington Knoll.

Refraction between Dover Castle and Calais Church.

73. Let C (fig. 6. Pl. XV.) be the earth's centre, SS the surface; D the station on Dover Castle; B the top of the great balustrade of Calais Steeple; DO the horizontal line; also let $Sd = SD$; then the angle $ODd =$ half the angle C, or arc SS.

Calais from Dover is 137455 feet, which answers to 22′ 29″ nearly, the angle C, or contained arc, therefore $ODd = 11' \ 14''\frac{1}{2}$.

		Feet.
The height of D above low-water spring tides	-	469
The height of B (communicated by the French Gentlemen)	- - - -	$140\frac{1}{2}$
	$Bd =$	$328\frac{1}{2}$

The distance 137455 with $328\frac{1}{2}$ give the angle $dDB =$		8′ 14″
	angle $ODd =$	11 $14\frac{1}{2}$
The depression, supposing no refraction, -	$ODB =$	19 $28\frac{1}{2}$
But the depression, by observation, was		17 59
Refraction - - -	diff.	1 $29\frac{1}{2}$

or $\frac{1}{15}$ of the contained arc. Which may be considered as the actual refraction at that time, because the relative heights are given.

Refraction between Padlesworth and the Horizon of the Sea.

74. Oct. 7, 1787, at the station near Padlesworth, the depression of the horizon of the sea, in a S W direction nearly, was

observed 26′ 27″. A degree of a great circle in that direction is about 61000 fathoms, and therefore $61000 \times 6 \times 57.2957795 = 20970255$ feet, will be the radius of curvature nearly. The height of the station above low-water spring tides (as determined by alternate observations at this place and Dover Castle) is 642 feet; hence $\frac{20970255}{20970255+642} = .9999693861$ the natural cosine of 26′ 54″ the *dip;* therefore 26′ 54″ — 26′ 27″ = 27″, is what the horizon was elevated by refraction. The state of the tide, however, is not taken into consideration, but the time was about noon. The weather was calm and cloudy, and the horizon clear. Barom. 29.6. Thermom. 70°, at one P. M.

This refraction coming out so small, might almost induce one to suspect that some error had crept into the observation, though it was made with much care and attention.

75. *Table of the Refractions, and vertical Heights.*

Mean Refr.			Instrum. above low-water.
$\frac{1}{2}$	of the contained arc between	Allington Knoll	329 feet.
		and Ruckinge	37
$\frac{1}{6}$	— —	High Nook	28
		and Lydd	130
$\frac{1}{6}$	— —	Allington Knoll	
		and High Nook	
$\frac{1}{7}$	— —	Allington Knoll	
		and Tenterden	322
$\frac{1}{8}$	— —	Paddlesworth	642
		and Lydd	
$\frac{1}{8}$	— —	Frant	659
		and Botley Hill	880
$\frac{1}{10}$	— —	Dover Castle	469
		and Padlesworth	

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Mean Refr.				Instrum. above low-water.
$\frac{1}{10}$ of the contained arc between			Fairlight Down and Tenterden	599 feet.
$\frac{1}{11}$	—	—	Goudhurst and Frant	497
$\frac{1}{12}$	—	—	Tenterden and Lydd	
$\frac{1}{13}$	—	—	Fairlight Down and Lydd	
$\frac{1}{18}$	—	—	Goudhurst and Tenterden	
$\frac{1}{22}$	—	—	Allington Knoll and Lydd	
$\frac{1}{24}$	—	—	Dover Castle and Folkstone Turnpike	575
$\frac{1}{7}$	—	—	Folkst. Turnpike and Calais	
$\frac{1}{15}$	—	—	Dover Castle and Calais	
$\frac{1}{17}$	—	—	Folkstone Turnpike and Montlambert	
			Greenwich Observatory	214
			Severndroog Castle	482
			Norwood	389
			Hundred Acres	443
			Hanger Hill Tower	251
			Hampton Poorhouse	101
			King's Arbour	132
			St. Ann's Hill	342
			Swingfield	530
			Hollingborn Hill	616

Remarks.

The refractions on the distances across the Channel, depend upon the heights on the opposite coast communicated by the

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French Gentlemen: that at Calais was determined by actual measurement.

There is reason to suppose that the height of St. Ann's Hill, in the above table, is considerably too great: it was found from that of Hampton Poorhouse, by taking $\frac{1}{10}$ of the contained arc for the effect of refraction. In 1787, at Hampton Poorhouse, the ground at St. Ann's Hill was elevated 17′ 39″, but in 1792, at the same station, the elevation was no more than 8′ 11″. By the barometer, the height of St. Ann's Hill was found to be 200 feet above the Thames at Shepperton, to which, adding 33 feet, for the fall to low-water at the sea, and 21 feet for the height of the telescope above the ground at St. Ann's Hill, the sum is 254 feet; which probably is within 30 feet of the truth.

N. B. When the instrument stood on the ground, the height of the telescope was about $5\frac{1}{2}$ feet. On the half scaffold it was 21 feet. And on the whole scaffold $37\frac{1}{2}$ feet from the ground.

Secondary Triangles, subdivided into two Sets, for the Improvement of the Maps of the Country, and the Plan of the City of London and its Environs. Plate XVI.

76. In the series of great triangles, the extreme smallness of the error on the sum of the three angles of each triangle sufficiently proves that the general result would not have differed greatly, if only two of the angles had actually been observed. But in an operation of so much importance, this could not have been depended upon; nothing was to be left doubtful; and therefore, in the execution of the various parts, the most minute attention was paid to every circumstance whereby the accuracy might be affected, and particularly to the placing of the lights and in-

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strument reciprocally over the same point marking the station, that no possible error might arise from parallax or eccentricity.

From this mode of conducting the operation, it will readily be seen, that, if time had permitted, the situation of a multitude of other points in the country might have been very accurately determined, besides those actually marking the points of the triangles, whereby the ordinary maps would have been greatly improved by such as chose at any time hereafter to make use of these as so many given distances. But the circumstances not having permitted us to multiply those points to the extent that might have been wished, and that would have been easily practicable, if the operation had commenced at an earlier season of the year: we have therefore been obliged to limit the number to a few of the most conspicuous and best defined objects.

These secondary triangles are subdivided into two sets. The first set consists of thirty-three, whereby the relative distances of so many points have been determined from certain stations of the principal series, beginning with those objects that have been intersected from the most westerly stations, and so on, proceeding gradually with the others towards the east. Two angles only of each of those triangles being observed, the third is that at the intersected object, or the supplement to 180°. Although the distances thus obtained cannot be quite so accurate as the sides of the principal series; yet there is no reason to apprehend, that they will be found to differ widely from the truth, when they come to be proved in the course of any subsequent operation, by which alone they can be put to the test.

Computation of the first Set of Secondary Triangles.

Triangles.	Angles.	Distances of the stations from the intersected object in feet.	
King's Arbour - St. Ann's Hill - *Stanwell Church*	° ′ ″ 8 52 57 4 4 44 167 2 19	from Stanwell	10927 23720
King's Arbour - Hanger Hill Tower *Harrow on the Hill* -	28 35 34 89 23 52 62 0 34	from Harrow on the Hill	42943 20553
King's Arbour - Hanger Hill Tower *Banstead Church* -	70 1 47 82 19 25 27 38 48	from Banstead Church	80992 76811
Hampton Poorhouse King's Arbour - *Kew Pagoda* -	88 58 23 40 14 25 50 47 12	from Kew Pagoda -	22849 35364
Harrow on the Hill St. Paul's Church - Spring Grove House, Sir Jo. Banks * -	69 43 8 35 58 9 74 18 43	from Spring Grove House -	35850 57253
Hanger Hill Tower Spring Grove House * *Richmond Royal Observatory* - -	19 33 4 82 46 16 77 40 40	from Richmond Royal Observ. Hanger Hill from Spring Grove	20164 6802 19857
Hundred Acres - St. Paul's * - *Battersea Church* -	14 13 27 34 3 49 131 42 44	from Battersea Church -	50664 22226
Hundred Acres - Fulham Church * *Stretham Church* -	27 51 56 46 12 54 105 55 10	from Stretham Church	35957 23279
Hundred Acres - Severndroog Castle Clapham Common, Mr. Cavendish -	36 59 36 33 28 20 109 32 4	from Clapham Common	43351 47295

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Triangles.	Angles.	Distances of the stations from the intersected object in feet.	
Norwood - - Severndroog Castle *Argyll Street Observatory, Major Gen. Roy*	76° 19′ 15″ 52 41 37 50 59 8	from Argyll Street Observatory	40082 48963
Norwood - - Severndroog Castle *St. Paul's Church* -	62 30 24 57 8 8 60 21 28	from St. Paul's Church -	37840 39962
N. B. By combining the results of these two last triangles a third is formed, which gives for the distance of Argyll Street from St. Paul's - - - - -			9632
And from this triangle and the VIII, the angle at Greenwich in the next triangle is obtained.			
Norwood - - *Greenwich Observatory* *St. Paul's* - -	42 15 27 82 41 1 55 3 32	from St. Paul's	25655
Norwood - - Severndroog Castle *Bromley Church* -	36 36 32 32 52 48 110 30 40	from Bromley Church -	22695 24930
Norwood - - Severndroog Castle *Chislehurst Church* -	31 53 3 67 48 12 80 18 45	from Chislehurst Church -	36777 20981
Geeenwich Royal Observatory - Severndroog Castle *West Pediment of Wanstead House* -	92 38 14 64 46 33 22 35 13	from Wanstead House -	34412 37999
Greenwich Royal Observatory - Severndroog Castle *Loampit Hill* -	131 45 43 14 7 0 34 7 17	from Loampit Hill -	6352 19428

Triangles.	Angles.	Distances of the stations from the intersected object in feet.	
	° ′ ″		
Greenwich Royal Observatory - Severndroog Castle *Eltham Church* -	22 41 33 87 18 31 69 59 56	from Eltham Church	15531 5998
Severndroog Castle Botley Hill - *Knockholt Beeches* -	21 56 44 54 48 27 103 14 49	from Knockholt Beeches -	58932 26950
Severndroog Castle Botley Hill - *Leith Hill Tower* -	31 40 29 124 53 14 23 26 17	from Leith Hill Tower -	144758 92666
Botley Hill - Frant Church - *Firedean Tower* -	39 17 16 26 58 39 113 44 5	from Firedean Tower	44780 62506
Botley Hill - Frant Church - *Crowborough Beacon*	19 51 20 77 32 33 82 36 7	from Crowborough Beacon	88975 30949
Botley Hill - Wrotham Hill - *Sevenoaks Windmill*	24 22 7 28 57 42 126 40 11	from Sevenoaks Windmill	44032 37519
Frant Church - Goudhurst Church *Wadhurst Church* -	46 5 9 26 21 46 107 33 5	from Wadhurst Church	20675 33540
Goudhurst Church Fairlight Down - *Brightling Windmill*	42 6 25 38 5 33 99 48 2	from Brightling Windmill	58618 63710
Fairlight Down - Lydd Church - *Rye Church* -	22 40 17 21 23 25 135 56 18	from Rye Church	37599 39735
Fairlight Down - Dover Castle, north turret - - *Dengeness Light House*	19 34 30 13 54 25 146 31 5	from Dengeness Light House	81086 113034
Fairlight Down - Goudhurst Church *Ore Church* -	60 29 28 4 12 42 115 17 50	from Ore Church	7606 90126

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Triangles.	Angles.	Distances of the stations from the intersected object in feet	
Fairlight Down -	23° 32′ 23″	from Fairlight Church -	5385
Lydd Church -	1 50 43		66790
Fairlight Church -	154 36 54		
Tenterden Church -	30 42 37	from Ashford Church -	51716
Allington Knoll -	56 45 7		31581
Ashford Church - -	92 32 16		
Lydd Church -	43 34 51	from Ruckinge Church -	41684
High Nook near Dymchurch - -	87 40 22		28759
Ruckinge Church -	48 44 47		
High Nook -	42 44 45	from Lymne Castle	20692
Allington Knoll -	60 21 48		16158
Lymne Castle -	76 53 27		
Lydd Church -	2 10 29	from Folkstone Church -	78950
Folkstone Turnpike -	27 26 22		6502
Folkstone Church -	150 23 9		
Folkstone Turnpike	24 35 59	from Beachborough Summer H.	23326
Padlesworth	123 46 35		11682
Beachborough Summer House - -	31 37 26		

Remarks.

The Royal Observatory in Richmond lower Park could not be seen from any of the stations of the great series of triangles, except Hanger Hill Tower, from whence the bearing of it was taken. In order to intersect this bearing, the assistance of certain operations made with the astronomical quadrant in 1783, at Spring Grove House, has been called in, by the help of which, the situations of the Observatory and of Spring Grove House have been determined. In like manner, the bearings of Battersea and Stretham, taken from the Hundred Acres, have been intersected with the quadrant from

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St. Paul's and Fulham. The stations where the quadrant was used are distinguished with asterisks.

		Observed angles.
At Hanger Hill; between Richmond Ob. and the Pagoda		12° 26′ 42″
At Spring Grove in 1783; between	Richmond Ob. and the Pagoda	13 10 13
	The Pagoda and St. Paul's	23 17 15
	St. Paul's and Harrow Spire	74 18 43
On Fulham Ch.; between	Stretham Ch. and St. Paul's	70 24 52
	St. Paul's and Hampstead Ch.	44 50 46
	Hampstead Ch. and Hanger Hill Tower	57 27 43
At the Hundred Acres; between	Hanger Hill and Battersea Ch.	23 59 44
	Hanger Hill and Stretham Ch.	42 3 57
On St. Paul's; between Battersea Ch. and the SW. Pinnacle of Westminster Abbey		0 9 46

The results from the observations made on Fulham Church, however, cannot be considered as very exact, because Hanger Hill Tower itself was the object, instead of the flag-staff placed on it in 1787.

Second Set of Secondary Triangles.

77. In the Philos. Trans. 1787, sufficient reasons have been given for avoiding St. Paul's as a station in the series of great triangles. Indeed, if no other objection had existed, the smoke of the capital alone would have been found extremely inconvenient. This was experienced at Shooter's Hill, where we were detained a whole week, before the white lights, notwithstanding their extraordinary brilliancy, could be seen at Hanger Hill Tower, or even at Argyll Street, the north-east wind, which then prevailed, having brought the impenetrable mass of smoke between the station of the instrument and the points to be observed; and at last we were obliged to watch all night, till towards the morning, the fires of

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London being extinguished, the white lights could then be intersected.

It is not therefore surprising, that from the stations of Norwood, Greenwich, and Shooter's Hill, we should only be able to fix, in a satisfactory manner, two points in London, namely, St. Paul's and Argyll Street. Bearings, it is true, of others were taken ; but that these might be intersected by angles not too acute, it became necessary to make use of observations that had been formerly obtained at Argyll Street, and at St. Paul's, with the astronomical quadrant. Moreover, by way of finishing the operation, and furnishing such part of the inhabitants of the metropolis as may be curious in matters of this sort with a set of distances that cannot fail to be useful to them, two new stations were chosen for the great instrument to the northward of London, one on *Hornsey Hill*, and the other on *Primrose Hill*. Thus, from the combined operations at these several places, we have been able to determine the situation of thirty conspicuous points, consisting chiefly of the most remarkable steeples in and near the capital.

By referring to Plate XVI. which is in fact the skeleton, but on a very small scale, for an improved plan of London and its environs, the relative situations of these points, with regard to St. Paul's and the four nearest stations of the great series, will be seen. Some of the principal of these secondary triangles have been represented by dotted lines in the plan. To have expressed more of them in that way, would only have occasioned confusion. Here it is to be remarked, that the distance of Argyll Street from St. Paul's, 9632 feet, (p. 184.) becomes a base in the quadrilateral formed by *St. Paul's*, *Argyll Street*, *Hornsey Hill*, and *Primrose Hill*. Hence, by the observed angles at these two last stations, and the assumed length of one of the unknown sides, all the angles of the quadrilateral are computed ; by which means, and the true length of one side given, the true lengths of all the others are readily obtained.

Computation of the second Set of Secondary Triangles.

Situations determined with the great instrument from Hornsey Hill and Primrose Hill.

Triangles.	Angles.	Distances of the stations from the intersected object in feet.	
Hornsey Hill -	46° 42′ 41″	from St. Paul's Church -	23297
Primrose Hill -	83 21 27.5		17072.5
St. Paul's -	49 55 51.5	Hornsey Hill from Primrose Hill	17949
Hornsey Hill -	23 8 34	Argyll Street Observatory	23803
Primrose Hill -	112 49 57		10150.5
Argyll Str. Observ.	44 1 29		
Hornsey Hill -	23 33 59	from Hampstead Church -	17972
Primrose Hill -	78 23 43		7335
Hampstead Church	78 2 18		
Hornsey Hill -	29 11 4	from Mr. Duveluz's Cupola -	7198
Primrose Hill -	16 44 50		12181
Mr. Duveluz's Cupola, Hornsey Lane, Highgate -	134 4 6		
Hornsey Hill -	47 30 42	from Islington Church -	14272
Primrose Hill -	51 42 39		13409
Islington Church -	80 46 39		
Hornsey Hill -	55 28 32	from Highbury House -	8868
Primrose Hill -	29 28 52		14845
Highbury House, Mr. Aubert -	95 2 36		
Hornsey House	50 52 33	from St. Luke's Church -	19323
Primrose Hill -	68 59 37		16057
St. Luke's Church, Old Street -	60 7 50		
Hornsey Hill -	62 9 30	from St. Leonard's Church	19816
Primrose Hill -	63 36 33		19560
St. Leonard's Ch. Shoreditch -	54 13 57		

	Triangles.	Angles.	Distances of the stations from the intersected object in feet.	
With the great instrument from Hornsey Hill and Primrose Hill.	Hornsey Hill -	61 19 8	from Christ Ch. Spitalfields -	22733
	Primrose Hill -	70 33 39		21149
	Christ Church, Spitalfields -	48 7 13		
	Hornsey Hill -	49 20 39	from Bow Ch.	23404
	Primrose Hill -	81 21 4		17959
	Bow Ch. Cheapside	49 18 17		
	Hornsey Hill -	42 33 43	from St. Bride's Church -	23158
	Primrose Hill -	86 44 24		15689
	St. Bride's Church, Fleet Street -	50 41 53		
	Hornsey Hill -	31 16 11	from S. George's Church -	21977
	Primrose Hill -	94 11 25		11438
	St. George's Church, Bloomsbury -	54 32 24		
	Hornsey Hill -	29 32 9	from St. Giles's Church -	22978
	Primrose Hill -	100 13 30		11510
	St. Giles's Church	50 14 21		
	Hornsey Hill -	28 2 38	from St. Ann's Church -	24197
	Primrose Hill -	106 40 20		11875
	St. Ann's, Soho -	45 17 2		
One angle taken with the great instrument, and the other with that in Argyll Street Observatory.	Hornsey Hill -	59 52 55	from Highgate Chapel -	9238
	Argyll Street Observatory -	22 37 48		20766
	Highgate Chapel -	97 29 17		
	Primrose Hill -	20 43 50	from St. Clement's Church	14391
	Argyll Str. Observ.	123 0 9		6074
	St. Clement's Ch.	36 16 1		
	Primrose Hill -	17 52 31	from St. Mary's Church -	14148
	Argyll Street Ob.	127 21 15		5463
	St. Mary's Church in the Strand -	34 46 14		
	Primrose Hill -	7 32 8	from St. Martin's Church	13631
	Argyll Street Ob.	152 0 27		3809
	St. Martin's Church in the Fields -	20 27 25		

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	Triangles.	Angles.	Distances of the stations from the intersected object in feet.	
One angle with the great instr. and the other with that in Argyll Street Obs.	Primrose Hill -	3° 13′ 0″	from the Pantheon -	10295
	Argyll Street Observatory -	102 32 39		592
	Pantheon -	74 14 21		
A small Hadley's sextant used in Argyll Street.	Primrose Hill -	5 35 34	from S. George's Church -	10816
	Argyll Street Ob.	120 13 56		1220
	St. George's Church, Hanover Square	54 10 30		
	Primrose Hill -	16 7 10	from South Audley Chapel	11359
	Argyll Street Ob.	103 34 59		3244
	South Audley Chapel	60 17 51		
A small Hadley's sextant used at St. Paul's.	Hornsey Hill -	38 14 6	from Newington Church -	8136
	St. Paul's Church	16 35 7		17640
	Newington Church	125 10 47		
	Hornsey Hill -	20 29 59	from St. Matthew's Church	21321
	St. Paul's Church	66 7 5		8166
	St. Matthew's Ch. Bethnal Green	92 22 56		
The astronomical quadrant used at St. Paul's in 1783.	Hornsey Hill -	18 22 9	from S. George's Church, Ratcliff	27045
	St. Paul's Church	105 32 24		8846
	St. George's, Ratcliff	56 5 27		
	Primrose Hill -	30 44 17	from St. James's Church -	12562
	St. Paul's Church	45 39 31		8978
	St. James's Church	103 36 12		
	Primrose Hill -	14 33 10	from Limehouse Church -	31374
	St. Paul's -	149 20 0		15456
	Limehouse Church	16 6 50		
	Argyll Street Ob.	61 47 27	from St. Peter's Church, Westm.	6279
	St. Paul's Church	39 42 24		8662
	SW. pinnacle of the S. tower of St. Peter's Ch. Westm.	78 30 9		
Great instr. and Argyll Street instrument.	Norwood -	18 5 5	from the Monument -	36409
	Argyll Street Ob.	64 9 56		12557
	The Monument	97 44 59		

	Triangles.	Angles. ° ′ ″	Distances of the stations from the intersected object in feet.	
Both with the astronomical quadrant.	Jew's Harp station	52 52 53	from St. Paul's Church -	13522
	Black Lane station	92 12 30		10790
	St. Paul's Church	34 54 37	from Jew's Harp to Black Lane, the base of 1783 -	7744
One angle with the Argyll Street instrument, and the other with the astronomical quadrant.	Jew's Harp station	89 56 56	from Argyll Street	5657
	Black Lane station	36 9 50		9586
	Argyll Street Observatory -	53 53 14		
	Argyll Street Ob.	95 30 56	from the British Museum	3488
	Jew's Harp station	30 5 26		6925
	Wind Vane *of the British Museum*	54 23 38		
	Argyll Street Ob.	74 26 17	from Charlotte Street Chapel	1848
	Jew's Harp station	19 1 56		5459
	Charlotte Street Chapel -	86 31 47		
Both angles observed with the astronomical quadrant in 1783.	Jew's Harp station	85 27 45	from Portland Chapel -	4098
	Black Lane station	28 53 30		8474
	Portland Chapel	65 38 45		
	Jew's Harp station	60 43 55	from Fitzroy Chapel -	4015
	Black Lane station	31 12 45		6759
	Fitzroy Chapel -	88 3 20		
	Jew's Harp station	63 25 50	from the Tabernacle -	4781
	Black Lane station	37 14 40		7048
	Tabernacle -	79 19 30		
	Jew's Harp station	19 45 45	from the Small-Pox Hospital	6670
	Black Lane station	56 57 45		2690
	Small-Pox Hospital	103 16 30		
	Jew's Harp station	4 41 45	from St. Pancras Church -	5728
	Black Lane station	12 58 25		2089
	St. Pancras Church	162 19 50		

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78. That these secondary triangles may be more generally useful to the inhabitants of London and its environs, the angles, which the 53 points comprehended in Plate XVI. respectively form with each other at the centre of the dome of St. Paul's, are collected in the annexed table, together with their several distances from that central point. The objects are arranged into two classes, according as they are situated to the eastward or westward of the meridian of St. Paul's. Those of the first class commence at the north meridian, and proceed by the east to 180°. These of the second commence at the south meridian, and proceed, in like manner, by the west to 180°. From this table the total angle between any two objects being had by simple subtraction, and the distances from St. Paul's given, the distances of the objects from each other are readily obtained. Whoever, therefore, should be desirous of knowing accurately his own situation in this great metropolis, may easily satisfy himself, by taking two angles from the top of his house with a good Hadley's sextant or theodolite, between any known objects near to him and the best disposed for the purpose. By the help of these *data*, and a very simple trigonometrical computation, he will obtain what he wants; and he may even satisfy another curiosity which will probably occur, namely, that of putting to the test our original operation, by trying how nearly different triangles bring out the same result. It will readily be conceived that, for trials of this sort, the points whose situations have been determined by the great instrument should be chosen preferably to the others; and next to these, the objects that have been fixed by one angle, taken with the Argyll Street instrument, as more to be relied upon than those observed with the astronomical quadrant or sextant. Thus an excellent foundation is laid for the improvement of the plan of London and its environs, which may by these triangles be rendered more accurate than would have been possible by any other mode.

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Table, shewing the Bearings and Distances of Objects situated in and near London, from the Centre of the Dome of St. Paul's.

Objects.	Bearings from the north meridian eastward.	Distances in feet.
Eastward from the Meridian of St. Paul's.	° ′ ″	
Newington Church	9 59 39	17641
St. Luke's Church, Old Street	12 37 37	4263
St. Leonard's Church, Shoreditch	44 54 59	6743
The West Pediment of Wanstead House	55 53 46	36308
St. Matthew's Church, Bethnal Green	59 31 37	8166
Christ Church, Spitalfields	70 38 37	5878
Bow Church, Cheapside	87 48 4	1078
Limehouse Church	92 58 41	15456
St. George's Church, Ratcliff Highway	98 56 56	8846
The Monument	115 15 46	3114
Severndroog Castle, Shooter's Hill	115 25 50	39962
Transit-room of Greenwich Royal Observat.	120 43 46	25655
Eltham Church	123 46 4	41090
Loampit Hill	134 40 49	23450
Station at Norwood	175 47 18	37840
South Meridian of St. Paul's	180 0 0	
Westward from the Meridian of St. Paul's.		
Stretham Church	13 57 8	31739
Clapham Common, Mr. Cavendish	26 29 52	24563
Battersea Church	52 22 28	22226
St. Peter's Church, Westminster, SW. pinnacle of the S. Tower	52 32 13	8662
Fulham Church	57 39 45	30746
Kew Pagoda	71 2 36	47577
Richmond Royal Observatory	71 42 0	51940
St. Martin's Church, in the Strand	74 28 59	6748
Spring Grove House, Sir Jos. Banks, Bart.	76 9 49	57253
St. James's Church	77 49 10	8978

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Objects.	Bearings from the south merid. westward.	Distances in feet.
	° ′ ″	
South Audley Chapel - -	81 49 43	12211
St. Mary's, New Church in the Strand	81 57 28	4291
St. Clement's Church - - -	85 57 37	3592
St. Ann's Church, Soho - -	86 9 59	7754
St. George's Church, Hanover Square	86 23 13	10304
St. Bride's Church, Fleet Street -	90 12 43	1687
Argyll Street Observatory, Maj. Gen. Roy	92 14 38	9632
The Pantheon - - - -	93 19 17	9067
Hanger-hill Tower - -	94 25 0	45844
St. Giles's Church - - -	94 36 28	6917
Portland Chapel - - -	100 34 39	10301
Charlotte Street Chapel - -	101 30 24	8500
St. George's Church, Bloomsbury Square	103 15 50	6221
Wind Vane of the British Museum -	105 45 46	6701
The Tabernacle, Tottenham Court Road	107 19 47	8776
Fitzroy Chapel - - -	109 41 10	9560
Harrow on the Hill Church - -	112 7 58	58763
Jew's Harp station of 1783 - -	112 58 31	13522
Primrose Hill station of 1788 -	123 28 41	17072
Hampstead Church - -	128 56 12	24148
St. Pancras Church - - -	136 43 26	10600
The Small-Pox Hospital - -	137 38 38	8732
Black Lane station of 1783 - -	147 53 8	10790
Highgate Chapel - - -	150 59 18	24062
Mr. Duveluz's Cupola, Highgate -	155 27 13	22646
Hornsey Hill station of 1788 -	173 24 32	23297
Islington Church - -	174 40 21	9028
Highbury House, Mr. Aubert -	178 43 15	14595
Ditto, the Transit-room of his Observatory	179 1 57	14561
North meridian of St. Paul's	180 0 0	- -

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The bearing of Greenwich from the meridian of St. Paul's, on which the other bearings in the above table depend, was found as follows:

St. Paul's bears from Greenwich 59° 11′ 43″ NW; distant from the meridian 22035 feet; and 13138 feet from the perpendicular; answering to 3′ 35″.9, and 2′ 9″½ respectively; the latter taken from 38° 31′ 20″ the co-lat. of Greenwich, leaves 38° 29′ 10″½; which, with 3′ 35″.9 as the legs of a spherical triangle, give 89° 55′ 29″ for the angle at St. Paul's, between its meridian and the perpendicular to that of Greenwich, which added to 30° 48′ 17″, (the complement of 59° 11′ 43″) makes 120° 43′ 46″, as in the table.

79. *Table, containing the Bearings of Thirty-two of the interior Objects from the Parallels to the Meridian of Greenwich; also their Distances from that Meridian and its Perpendicular.*

Objects.	Bearings.				Distances from Meridian.	Distances from Perpend.
At Greenwich Ob.	°	′	″		Feet.	Feet.
Wanstead House	13	32	13	NE	8055	33456
Eltham Steeple	51	8	1	SE	12093	9746
St. Paul's	59	11	43	NW	22035	13138
At Norwood.						
Argyll Street	17	57	1	NW	31662	13528
At the Hundred Acres.						
Clapham Common	13	45	28	NE	33023	8830
At King's Arbour.						
Harrow Spire	36	57	53	NE	76441	35350
Kew Pagoda	84	39	11	SE	67053	2257
Banstead Spire	44	24	46	SE	45582	56817
At St. Ann's Hill.						
Windsor Castle	29	19	25	NW	137048	2563
Stanwell Spire	25	45	5	NE	109094	7488

Objects.	Bearings.				Distances from Meridian.	Distances from Perpend.
At St. Paul's.	°	′	″		Feet.	Feet.
Spring Grove House	76	14	20	SW	77645	481
Richmond Observatory	71	46	31	SW	71370	3106
Battersea Steeple	52	26	59	SW	39656	407
Stretham Steeple	14	1	39	SW	29728	17654
Highbury Transit R.	0	53	32	NW	22262	27697
St. James's Church	77	53	41	SW	30813	11255
At Severndroog Castle.						
Bromley Church -	25	29	25	SW	3303	26573
Chiselhurst Steeple	9	26	0	SE	17471	24767
Leith Hill Tower -	43	3	47	SW	84809	109831
At Botley Hill.						
Sevenoaks Windmill	76	21	24	SE	42962	83267
At Frant.						
Wadhurst Steeple	51	30	40	SE	78523	151325
Fairden Tower -	70	26	59	NW	3439	117541
At Goudhurst.						
Brightling Windmill	18	51	8	SW	87404	188069
Ore Church - -	19	2	35	SE	135751	217790
At Fairlight Down.						
Rye Steeple - -	44	24	41	NE	169624	191760
Dengeness Light House	79	8	4	NE	222944	203333
Fairlight Church -	89	22	39	SE	148697	218676
At Tenterden.						
Ashford Steeple -	55	4	28	NE	200723	118963
At Lydd.						
Ruckinge Church -	6	30	22	NW	204622	149285
Folkstone Church -	52	59	51	NE	272395	143185
At Padlesworth.						
Beechborough Sum. H.	59	27	48	SW	251653	136775
At High Nook.						
Lymne Castle -	21	42	56	NE	235909	146454

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The bearings and distances in the foregoing table, have been obtained in a similar manner to those in the table, Art. 59; thus, taking Windsor Castle for an example:

If a line be drawn through St. Ann's Hill parallel to the meridian of Greenwich, (see the Plan of the triangles) then the bearing of King's Arbour from that line will be $29^\circ\ 49'\ 49''$ NE.

The angle at St. Ann's Hill between King's Arbour and Windsor Castle (triang. III. Art. 57.)	59 9 14
Bearing of Windsor Castle from the parallel to the meridian of Greenwich - diff.	29 19 25 NW.

The sine and co-sine of $29^\circ\ 19'\ 25''$, with 36032 feet, the distance of Windsor from St. Ann's, as radius, give 17646 feet for what Windsor is westward, and 31415 feet, what it is northward from St. Ann's.

	Feet.
St. Ann's Hill from the meridian of Greenwich (59)	119402
add	17646
Windsor Castle from the meridian of Greenwich	137048
St. Ann's Hill from the perpendicular (southward)	28852
	31415
Windsor Castle from the perpendicular (northward) diff.	2563

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80. *Computed Latitudes and Longitudes of the interior Objects in the foregoing Table.*

Objects.	Lat.	Long. from Greenwich.	In time.
		West.	
	° ′ ″	° ′ ″	m. s.
St. Paul's - -	51 30 49	0 5 47	0 23.1
Highbury House Trans. R.	51 33 13	0 5 51	0 23.4
Stretham Steeple -	51 25 46	0 7 48	0 31.2
St. James's Church -	51 30 31	0 8 5	0 32.3
Argyll Street Ob. -	51 30 53	0 8 19	0 33.3
Clapham Common	51 27 13	0 8 40	0 34.7
Battersea Steeple -	51 28 36	0 10 24	0 41.6
Banstead Steeple -	51 19 19	0 11 55	0 47.7
Kew Pagoda - -	51 28 16	0 17 36	1 10.4
Royal Ob. Richmond	51 28 8	0 18 43	1 14.9
Harrow Steeple -	51 34 27	0 20 6	1 20.4
Spring Grove House	51 28 34	0 20 22	1 21.5
Leith Hill Tower -	51 10 35	0 22 7	1 28.5
Stanwell Steeple -	51 27 23	0 28 37	1 54.5
Windsor Castle -	51 29 0	0 35 28	2 21.9
		East.	
Bromley Church -	51 24 18	0 0 52	0 3.5
Fairden Tower - -	51 9 21	0 0 54	0 3.6
Wanstead House -	51 34 10	0 2 7	0 8.5
Eltham Spire - -	51 27 4	0 4 30	0 18
Chiselhurst Steeple	51 24 36	0 4 35	0 18.3
Sevenoaks Windmill	51 14 29	0 11 13	0 44.9
Wadhurst Steeple -	51 3 46	0 20 25	1 21.7
Brightling Windmill	50 57 44	0 22 41	1 30.7
Ore Church - -	50 52 48	0 35 10	2 20.7
Fairlight Church -	50 52 38	0 38 31	2 34
Rye Steeple - -	50 57 1	0 44 0	2 56
Ashford Steeple -	51 8 56	0 52 18	3 29.2
Ruckinge Church -	51 3 56	0 53 13	3 32.9
Dengeness Light House	50 55 1	0 57 48	3 51.2
Lymne Castle - -	51 4 20	1 1 22	4 5.5
Beechborough Summer H.	51 5 53	1 5 30	4 22
Folkstone Church -	51 4 47	1 10 52	4 43.5

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AN

ACCOUNT

OF THE

TRIGONOMETRICAL SURVEY

CARRIED ON IN THE

YEARS 1791, 1792, 1793, AND 1794,

BY ORDER OF THE DUKE OF RICHMOND,

THEN MASTER GENERAL OF THE ORDNANCE.

BY

LIEUT. COL. EDWARD WILLIAMS,

AND

CAPT. WILLIAM MUDGE,

OF THE ROYAL ARTILLERY;

AND

MR. ISAAC DALBY.

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AN

ACCOUNT, &c.

INTRODUCTION.

81. A GENERAL Survey of the Island of Great Britain, at the public expence, was (as we learn from the Introduction to the account of the measurement on Hounslow Heath) under the contemplation of Government as early as the year 1763, the execution of which was to have been committed to the late Major General Roy, whose public situation and talents well qualified him for such an undertaking. Various causes procrastinated this event till the year 1783, when the late M. Cassini de Thury transmitted a memoir to the French ambassador at London, which paved the way to a beginning of this important work. Calculated for the advancement of science, this memoir was presented to the King, and readily met with the approbation of a monarch, so eminently distinguished, from the æra of his reign, for his liberal patronage of the arts and sciences. By his Majesty's command, the memoir was put into the hands of Sir Joseph Banks, P. R. S. accompanied with such marks of royal munificence, as speedily obtained all the valuable instruments and apparatus necessary for carrying the design into immediate execution.

General Roy, to whose care the conduct of this important business was committed, lived to go through the several operations

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pointed out in the memoir, the particulars of which have been detailed in the two foregoing Accounts. The further prosecution of the Survey of the Island, to which the operations hitherto performed might be deemed only as subservient or introductory, seemed to expire with the General.

The liberal assistance which his Grace the Duke of Richmond had on all occasions given to this undertaking; and particularly the essential services performed by Captain Fiddes, and Lieutenant Bryce, of the corps of royal engineers, in the survey and measurement of the base of verification on Romney Marsh, are acknowledged by General Roy in the strongest terms. A considerable time had elapsed since the General's decease without any apparent intention of renewing the business, when a casual opportunity presented itself to the Duke of Richmond of purchasing a very fine instrument, the workmanship of Mr. Ramsden, of similar construction to that which was used by General Roy, but with some improvements; as also two new steel chains of one hundred feet each, made by the same incomparable artist. Circumstances thus concurring to promote the further execution of a design of such great utility, as well as honour, to the nation, his Grace, with his Majesty's approbation, immediately gave directions to prepare all the necessary apparatus for the purpose, which was accordingly provided in the most ample manner.

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An Account of the Measurement of a Base on Hounslow Heath, with an hundred Feet Steel Chain, in the Summer of the year 1791.

Preamble.

82. Previous to entering upon the ensuing account, it may not, perhaps, be improper to enumerate some preliminary matters relative to the subject. The first mode of mensuration adopted by General Roy was that with deal rods, which had also been used and approved of in other countries. In the course of the measurement, however, it appeared, that the sudden and irregular changes which these rods were liable to, from dryness, humidity, or other causes, rendered them totally unfit for ascertaining the length of the base with that degree of precision, of which it was at first thought they were capable. On this account they were laid aside, and glass rods substituted in their stead. These rods were contrived with great ingenuity to answer the purpose, as fully appears by the account given of them in Art. 4. But this mode of mensuration being the first of the kind, seemed to require some proof of its accuracy, which consideration induced General Roy to make a comparison between the glass rods and the steel chain, which Mr. Ramsden had made for the Royal Society. For this purpose a distance of one thousand feet was carefully measured with the rods and the chain. The result of these measurements appeared to be such as would have produced a difference of little more than half an inch upon the whole base, had it been measured with each of them respectively. But notwithstanding the apparent degree of accuracy which this, or any other mode of measuring may be supposed capable of, yet it seems necessary that every base, intended to become the groundwork of such nice

operations, ought always (when circumstances will permit) to be measured twice at least.

The manner in which the glass rods were applied in the measurement, is supposed to have rendered the operation liable to some small errors, which lying different ways, might possibly have counterbalanced each other, and produced a true result: but this supposition ought never to be admitted in experimental inquiries, unless such errors can be nearly estimated. The principal cause of error is supposed to arise from the ends of the two adjacent rods being made to rest on the same trestle; because when the first rod is taken off, the face of the first trestle, being then pressed by the end of one rod only, will acquire a tendency to incline a little forward. The error arising from this cause will evidently tend to shorten the apparent base.

Another source of error is supposed to arise from the casual deviation of the rods from a right line, in the direction of the base, tending to increase its apparent length. And a third error is supposed to result from the method which was used of supporting the ends of the rods on two trestles only, by which they become liable to bend in the middle. This concave form of the rods would also tend to lengthen the base. The first of these causes of error was submitted to experimental inquiry in the garden of Richmond house, Whitehall, in the presence of his Grace the Duke of Richmond, Sir Joseph Banks, Mr. Ramsden, and Mr. Dalby; when it appeared evidently, that the glass rod had a small motion when the other rod, which had counterbalanced it, was taken from the trestles.

These considerations, therefore, rendered it necessary to compare the measurement with the glass rods, with that performed by some other method; not on account of any doubt being entertained of the care with which General Roy's operation had been performed, but solely with a view to bring this new mode of measuring to some proper test. No method of comparison could,

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perhaps, be better than measuring the same base with the steel chain. General Roy himself, in his remarks on the comparative accuracy of the two bases, that of Hounslow Heath and Romney Marsh, evidently gives the preference to the chain; which, every circumstance considered, it is certainly right to do. These reasons induced his Grace the Duke of Richmond to direct the base on Hounslow Heath to be remeasured with the steel chain; and although the result does not differ from the glass rods by so small a quantity as General Roy's experiment assigned, yet it does not amount to more than three inches on a base exceeding five miles.

Of the Apparatus provided for the Measurement of the Base.

83. The apparatus, provided for the measurement, consisted of the following articles, *viz.*

1. A transit instrument.

2. A boning telescope.

3. Two steel chains, 100 feet each, with the apparatus for the drawing-post and weight-post.

4. Three sets of deal coffers, each coffer being nearly 20 feet long, for receiving the chain when extended in a right line.

5. Thirty-six strong oaken pickets of $3\frac{1}{2}$ and $4\frac{1}{2}$ feet long; shod, and hooped with iron.

6. Four brass register heads, carrying graduated sliders moved by finger-screws, for adjusting the ends of the chain. One of these registers has a micrometer-screw attached to it, proper for measuring small quantities expanded or contracted by the chain.

7. Thirty-six cast iron heads, to fix on the pickets.

As many of these articles have been described very circumstantially by General Roy in the two preceding Accounts, it will only be necessary here to give a description of the transit instrument, boning telescope, and the two new chains.

The Transit Instrument. Pl. XVII.

84. This instrument, made by Mr. Ramsden, may be considered as a transit combined with a telescopic level, which makes it serve two purposes; one for determining points in the same vertical plane; the other to show how much a measured line deviates from the level. It consists of a telescope about eighteen inches long, with an achromatic object-glass of about $1\frac{6}{10}$ inches diameter. The telescope passes through an axis in the manner of a transit, and as it must be used for viewing objects at very different distances, the images from the object-glass will vary in the same proportion; it therefore becomes necessary to vary the distance of the wires, so that they may be exactly in the same place with the image. For this purpose there is a pinion, moveable by turning a milled head at A, whereby the small tube, with the wires which are contained in the box B, are made to approach, or recede from the object-glass.

The two pivots, or extremities of the axis, are made with great accuracy to the same diameter; and they turn in angles in the uprights C and D. Each of the angles is fixed in a slider; one at D, to move horizontally, by turning a finger-screw E; the other vertically, by turning the finger-screw F.

The level G is here represented as suspended by its hooks on the transverse axis. Its use is to show when that axis is horizontal; and it is furnished with an adjusting screw H, by which the two hooks may be made exactly of the same length, so that the axis on which it is suspended may become parallel to a tangent to the middle of the glass tube. This level also serves to set the line of collimation in the telescope horizontal; for which purpose there are two pins, K and L, attached to the side of the telescope, parallel to the axis thereof: one of these pins is furnished with an

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adjusting-screw M, by which the line of the hooks is made parallel to the line of collimation in this direction, with the greatest precision. The level may be suspended on these pins in the same manner as on the horizontal axis.

The cross wires at N, in the common focus of the object and eye-glasses, are fixed at right angles to each other; but instead of being placed horizontally and vertically, as in the common way, they make each an angle of 45° with the plane of the horizon. This mode of fixing wires is of the greatest advantage in making nice observations, as it remedies the inconvenience and error arising from their thickness. To bring the line of collimation in the telescope at right angles to the horizontal or transverse axis, there are two nuts for the purpose, one on each side of the box at N, which serve to move the intersection of these wires towards the right or left.

In the eye end of the telescope is a micrometer, which serves to measure small angles of elevation or depression. It consists of a moveable horizontal wire, placed as close as possible to the cross wires already mentioned. By turning the micrometer-screw O, this wire is moved across the field of the telescope, and the space which it moves through is shown in revolutions of the micrometer-screw, by means of an index, moveable in a slit, and the divisions on the stem Q. The parts of a revolution are shown in 100ths by an index P, on the micrometer head.

In tracing out a base by intermediate stations, the instrument must be frequently shifted to the right or left, till the telescope shows that the middle of its axis and the extremities of the base are in the same vertical plane. To expedite this operation, there are slits cut through the top of the mahogany board, for receiving the screws which fasten the supports of the telescope; by which means the telescope, with its supports, can be moved a little to the right or left, whilst the stand remains fixed. Over another slit in

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the top, and directly under the centre of the axis of the telescope at R, is a small hole for a wire or thread to pass through, suspending a plummet for marking a point on the ground, when the telescope is brought into the desired vertical plane.

The method of levelling the axis, adjusting the line of collimation, &c. are similar to those for the upper telescope of the great theodolite, as described in Art. 44, &c.

Boning Telescope.

85. This telescope is in every respect the same as that which was made use of by General Roy, therefore it will only be necessary to explain the application of it, for fixing the pickets in the direction of the base, with the tops of those belonging to the same hypothenuse in the same right line.

A rope being stretched along the ground, in the direction of the base, distances of 100 feet were marked upon it by means of a twenty-feet deal rod. After a sufficient number of these distances were set off, the telescope was laid on a narrow piece of board, truly planed, and fixed to the top of the picket at the beginning of the hypothenuse; and another picket was driven into the ground at a convenient height at the other end. To the top of this last, a thin deal spar was fixed, and the telescope directed to it, whilst the intermediate pickets were driven to their proper height. To determine this height more accurately, another spar, whose thickness was equal to the height of the axis of the telescope above the top of the picket, which supported it, was repeatedly laid on the top of each picket at the time of driving it, till its upper edge and the fixed spar appeared in a right line. Whilst the pickets were driving, they were moved a little to the right or left, as directed by signals from the observer at the telescope, till their tops appeared in the same right line.

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The Chains.

86. These chains were made by Mr. Ramsden, and are of similar construction in the joints to that which he made for the Royal Society, described in Art. 3.; but they differ from that in other respects. Instead of one hundred links, each of these new chains contains forty, of $2\frac{1}{2}$ feet long. The link is in form of a parallelopipedon, of half an inch square, which renders it considerably stronger than that of the Royal Society; and the chain having fewer links, becomes less liable to apply itself to any irregularities which the coffers may be subject to. The handles are made of brass, and being perfectly flat on the under side, they move freely upon the brass register-heads, by which means the coincidence between the arrows at the extremities of the chain, and the divisions on the scales, are readily and accurately obtained. The two chains will hereafter be distinguished by the letters A and B.

On Saturday July the 23d, all the foregoing articles were conveyed from the Tower to the end of the base near King's Arbour, where tents were pitched for a party of the royal regiment of artillery, consisting of one serjeant and ten gunners, who were employed in the laborious part of the operation.

Experiments made to ascertain the relative Lengths of the Chains, before and after they were used; and also to determine the Expansion of one Chain; or one hundred Feet of blistered Steel, by one Degree of Fahrenheit's Thermometer.

87. For this purpose, two strong oaken pickets were driven two feet into very firm ground, and the drawing-post was made fast to them. Five coffers were arranged in a right line, and supported

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upon courses of bricks. The chain was then placed in the coffers, and stretched with a weight of fifty-six pounds. Notwithstanding the great resistance which it was thought these pickets were capable of, yet it was found insufficient to counteract the friction between the coffers and the chain, when the expansion or contraction took place. Three pickets, therefore, of forty-four inches long, were driven into the ground, within six inches of their tops, and the drawing-post was fastened to them by several folds of strong rope. The pickets and rope were also covered with earth, to prevent their being warped by the sun.

The micrometer-screw, attached to the brass register-head, by means of which the expansion or contraction was measured, contains 26 threads in an inch. The circular head is divided into 10 equal parts, and consequently each division will measure $\frac{1}{260}$th part of an inch. But as the eye readily subdivides each of the divisions into 4 parts, the micrometer will measure the $\frac{1}{1040}$th of an inch tolerably exact.

For finding the relative Lengths of the Chains.

88. In order to accomplish these experiments in the most unexceptionable manner, after the chain was properly stretched in the coffers, and the thermometers placed by it, the whole remained till all the thermometers stood steadily at the same height. The ends of the chain being then in perfect coincidence with particular divisions on the brass register-heads, the chain was quickly taken out and replaced by the other, which being properly stretched in a right line, and a coincidence made at the drawing-post end of the chain, the variation of the other end from the division on its register-head showed the difference of the lengths of the chains, which was measured with the micrometer. As it required weather particularly steady to succeed in these experiments, we were

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obliged to catch the most favourable opportunities that presented themselves, which happened on the 29th and 30th of July; on those days the chains were compared with each other, and the results were as follow.

July 29th. *Thermometers remaining steadily at 75° during and after the operation.*

The chain B was found to be $6\frac{1}{2}$ divisions of the micrometer head shorter than the chain A; and on being shifted, A was found to exceed B $6\frac{1}{2}$ divisions.

Same day. Thermometers steady at $67\frac{1}{2}°$.

The chain B 6 divisions shorter than A; and being shifted, the chain A was 6 divisions longer than B. The mean from these experiments is, A $6\frac{1}{4}$ divisions longer than B.

In the table containing the particulars of the operation it will be found, that the chain B was laid aside after measuring 38 chains, on account of one of the links appearing to be a little bent. Before it was sent to Mr. Ramsden it was compared with the chain A (at first intended to be kept as the standard chain), when it was found to be only $4\frac{1}{2}$ divisions longer; which being $1\frac{3}{4}$ divisions less than the mean $6\frac{1}{4}$ as found above, shows, that the chain B had lengthened $1\frac{3}{4}$ divisions in measuring 38 chains; for when Mr. Ramsden afterwards straightened the link, he could not perceive any difference in its length.

The remainder of the base was measured with the chain A (the chain B being kept as a standard), and when that was completed, a comparison was again made between A and B, when it appeared that A exceeded B by $14\frac{2}{10}$ divisions of the micrometer head; therefore the wear of A, by lengthening of the joints, in measuring 236 chains, was $14.2 - 4.5$ divisions $= 9.7$ divisions of the micrometer.

For finding the Rate of Expansion.

89. The chain being placed in a right line, along the horizontal bottoms of the coffers, and kept in a state of tension by a weight of fifty-six pounds, five thermometers were placed close by the chain; one in the middle of each coffer; and the whole was covered with a white linen cloth, when the sun shone out. After remaining a few minutes, till the thermometers were nearly of the same temperature, a perfect coincidence was made on the register heads, at each end of the chain, and the thermometers noted. Every thing remained in this state till the coincidence at the weight end of the chain was observed to be altered, and the thermometers nearly the same; at which instant, they were again read off, and the alteration of coincidence measured with the micrometer.

August 5th, cloudy.

Thermometers.							Total contr.	Contr. on 1°
1	2	3	4	5	Mean.	Micr. Divisions.	Inches.	Inches.
75.75 62.5	75.5 62.75	76 63	76.25 63	76 63	75.9 62.85	$25\frac{1}{8}$	.096642	.0074

Here the contraction of the chain is $25\frac{1}{8}$ divisions of the micrometer $= 25\frac{1}{8} \times \frac{1}{260}$ inches $=$ .096642 inch. and the corresponding variation of the thermometers, taking the difference of the means, is $13^{\circ}.05$; consequently the contraction on $1^{\circ} = \frac{.096642}{13.05} = .0074$ inch.

Aug. 6th, cloudy.

89.5 69.5	89.75 69.5	90 69.25	90 69	90.5 69.5	89.95 69.35	38.5	.148077	.00719

Aug. 7. Coffers covered with the linen cloth.

Thermometers.							Total contr.	Contr.
1	2	3	4	5	Mean.	Micr. Divisions.	Inches.	on 1°. Inches.
102.5	10.25	102.75	102	102	102.35	29.5	.113462	.00749
87	86	87	88	88	87.2	8	.030769	.00779
89	89.75	93	92	92	91.15	16.25	.062500	.00781
98	95	102	99.75	101	99.15	9.33	.035885	.00748
93	92	96	95	95.75	94.35			

Aug, 7th, in the evening. Coffers covered with the linen cloth.

90	91	89	91	92	90.6	19	.073077	.00746
80	80	81.5	81.5	81	80.8	23.5	.090385	.00735
67	68	69.5	69	69	68.5	13	.050000	.00746
60.75	62.75	62	62	62	61.8			

The mean result from these nine experiments is 0,007492, or 0.0075 inch to 1° of Fahrenheit, on 100 feet of blistered steel; which differs only $\frac{13}{100000}$th parts of an inch from General Roy's conclusion with the pyrometer; but the number .0075 is preferred in these measurements, as being deduced from experiments made with the chain itself.

Particulars relative to the Commencement of the Operation, &c.

90. After the chains were compared, and the rate of expansion determined, as related in the preceding article, several trials were made of arranging the pickets and coffers in such a manner as might be supposed proper for the reception of the chain. It was soon found, however, that this method of measuring would be neither so expeditious or accurate, as if the coffers were placed

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upon trestles, such as were made use of by General Roy in his measurement with the glass rods. An application was therefore made to Sir Joseph Banks, who very obligingly complied with the request, and lent the trestles belonging to the Royal Society. A description of them is given in Art. 6.

As the upper part of the pipe at the north-west end of the base was found to be exceedingly rotten, it became necessary to saw off 13 inches of it, which left enough of the cylinder remaining to fix the brass cup in, as it had been originally bored to the depth of two feet. This cup, which was also lent by the Royal Society, being inserted in the pipe, fitted it exactly.

On the 15th of August, having previously traced out the line of the base, by means of the transit instrument, the operation commenced, in the presence of Sir Joseph Banks, Dr. Maskelyne, and several other members of the Royal Society. The following table, which contains the particulars of it, will explain the order of time in which the different parts of the measurement were performed. As it would swell this table to a great extent, were the degrees shewn by the thermometers inserted therein, it has been considered as proper to give only their sum, which is sufficient for finding the correction to be applied in the reduction of the base, on account of the lengthening or contracting of the chain by variation of temperature. It may, however, be remarked, that the five thermometers were laid close by the chain, and suffered to remain till they had nearly the same temperature, when they were read off, and registered in a field book, whilst an observer at each end of the chain preserved a perfect coincidence between the arrow and a particular division on the brass scale. When the sun shone out, the chain was covered with a white linen cloth, the ends of which were put over the openings of the first and last coffers, to exclude the circulation of air. The thermometers usually remained in the coffers from 7 to 15

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minutes, according to circumstances; when the sky was much overcast, a shorter time generally was found to be sufficient.

91. *Table, containing the Particulars of the Measurement: the first Column showing the Day of the Month when each Hypothenuse was finished; the Second, the Number of Hypothenuses; the Third, the Number of Chains in each Hypothenuse; the Fourth, the Perpendicular belonging to each Hypothenuse, or the* datum *for reducing it to the Plane of the Horizon; the Fifth, the computed Reduction; the Sixth, the new Points of Commencement above or below the Head of the last Picket when a new Direction was taken; the Seventh, the total Descent of the Extremity of each Hypothenuse; and the Eighth, Remarks, or general Occurrences.*

N. B. The Numbers in the 4th and 6th Columns connected according to their signs + and —, give the total descent in the 7th Column.

1791. Month.	No. of hypoth.	No. of chs. in hypoth.	Perpendicular.	Reduction of hypothen.	New point of comm^t.	Total descent.	Remarks.
			Inches.	Inches.	Inches.	Inches.	
Aug. 15	1	3	+ 5.8	0.00467	+14.0	19.8	The 1st chain commenced 14
16	2	3	0.0	0.00000	+ 1.8	21.6	inches above the head of General Roy's pipe before it was
22	3	32	—57.	0.04231		35.4	cut off smooth.
23	4	14	+26.25	0.02051		61.65	Began measuring with chain A
25	5	10	+12.1	0.00610	— 4.9	68.85	at 4th hyp. one of the links on
29	6	19	0.0	0.00000	— 7.9	60.95	the chain B appearing to be a
Sept. 2	7	34	+28.8	0.01017		89.75	little bent. [8th hypot.
4	8	1	— 3.8	0.00602		85.95	Crossed the river Coln at the
6	9	15	+69.25	0.13321		155.20	Crossed the Staines road at the
8	10	17	+15.3	0.00574	— 4.25	166.25	9th hypothenuse.
9	11	5	+33.5	0.09352		199.75	
12	12	13	+ 1.9	0.00012		201.65	
12	13	7	+54.5	0.17680	— 8.25	247.90	
13	14	6	0.0	0.00000		247.90	
14	15	5	+ 7.5	0.00469	— 5.25	250.15	
14	16	9	0.0	0.00000		250.15	
16	17	8	+ 5.3	0.00146	— 9.8	245.95	
17	18	10	+ 2.9	0.00035		248.85	
20	19	5	+ 4.8	0.00192		253.65	
20	20	4	+ 8.1	0.00683		261.75	
21	21	8	— 1.5	0.00012		260.25	
21	22	6	+35.4	0.08703		295.65	
22	23	1	+ 6.4	0.01707		302.05	Crossed the Wolsey river at the
23	24	10	+14.5	0.00876		316.55	23d hypothenuse.
25	25	12	+54.4	0.10275		370.95	
25	26	1	—24.5	0.25015		346.45	
25	27	5	— 1.0	0.00001		345.45	
26	28	6	+11.3	0.01064		356.75	
26	29	1	+ 9.0	0.03375		365.75	The head of the last picket was 2¼ feet above the head of
26	30	5	+ 6.9	0.00397		372.65	the pipe before it was cut off smooth.
		Total reduction =		1.02867	=0.08572 feet.		

Sum of all the degrees shown by the thermometers = 96795.25.

Remarks.

92. It having been our wish, that some scientific persons should be present at the completion of the measurement, his Grace the the Duke of Richmond was pleased to desire Dr. Maskelyne, astronomer royal, and Dr. Hutton, professor of mathematics in the royal military academy at Woolwich, to attend upon this occasion; to whom Mr. Ramsden was necessarily joined, as his standard brass scale, and beam compasses, were requisite to conclude the business with the wished for accuracy. Accordingly, on Wednesday the 28th of September the remaining three chains were measured in their presence; and the horizontal distance from the end of the last chain to the axis of the pipe was found to be 21,055 inches, as determined by Mr. Ramsden; and consequently the apparent length of the base was 274 chains, and 21,055 inches.

The height of the last picket above the pipe was 35 inches, from which deducting the 5 inches of the rotten part, which was cut off, there remains 30 inches, or $2\frac{1}{2}$ feet, for the height of the last picket, above General Roy's pipe; which makes the whole descent 33,55 feet; or about $2\frac{1}{4}$ feet more than was determined by the former measurement.

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Reduction of the Base to the Temperature of 62°.

	Feet.
93. Apparent length, namely, 274 chains + 1.755 feet - - - - - - -	27401.755
The correction for the excess of the chains lengths * above 100 feet, and half their wear, is $\frac{236 \times .0956 + 38 \times .05489}{12}$; and this add - - -	2.0539
The sum of all the degrees shewn by the thermometers was 96795.25; therefore $\overline{\frac{96795.25}{5} - 54^\circ} \times 274 \times \frac{.0075}{12}$ is the correction for the mean heat in which the base was measured, above 54°, the temperature to which the chains were reduced; and this also add - - - - - -	2.8519
Hence these corrections, added to the apparent length, give - - - - -	27406.6608
Again, for the reduction of the base to the temperature of 62° we have $\frac{8^\circ}{12} \times 3.38938$; and this subtract	2.2596
By the table, the sum of all the corrections for reducing the several hypothenuses to the plane of the horizon is 1.02867 inches = 0.08572 feet; and this subtract - - - - - -	0.0857
Hence these corrections taken from the above length leaves that of the base in the temperature of 62°	27404.3155

Being about $2\frac{3}{4}$ inches greater than the measurement with the glass rods (17.); therefore 27404.2 feet, the mean of the two results, may be taken as the true length of the base.

* For the lengths of the chains A and B see the next Article.

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Mr. Ramsden's Method of ascertaining the actual Lengths of the Chains A *and* B. Pl. XVIII.

94. These chains were originally compared with the brass points inserted in the stone coping of the wall of St. James's churchyard; but the temperature at the time of that comparison was afterwards forgotten by Mr. Ramsden. After the mensuration on Hounslow Heath was finished, the chains were again compared with those points; but the result did not prove to be satisfactory, as there were reasons for supposing that some alteration had taken place in the length of the coping; but, independent of this, the great irregularities between the joints of the stones, some of which projected half an inch above others, rendered it at best a very rude and inaccurate operation. Mr. Ramsden had points remaining on his great plank, which had been transferred from the brass standard, but as the plank itself was found to be subject to a daily expansion and contraction, he turned his thoughts to the invention of some other method of measuring the lengths of the chains, in a more unexceptionable manner.

On considering that the expansion of cast iron is nearly the same as that of the steel chain, he procured a prismatic bar of that metal, of 21 feet long, judging it to be the most proper material for the present occasion, as well as for establishing a permanent standard for future comparisons of the same kind. The manner in which the bar was fitted up for the purpose will be readily understood by attending to Pl. XVIII.

The great plank was cut to the length of about 22 feet, and on one of its narrow edges 21 brackets were fixed; each of which had a triangular notch to receive and support the bar, with one of its angles downwards, so that the upper surface became one of the faces of the prism. Before the brass points were inserted in this

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bar, Mr. Ramsden compared his brass standard with that belonging to the Royal Society, for which purpose, on Nov. 22d, 1791, it was sent to their apartments in Somerset house, where, after the two standards had remained together about 24 hours, they were found to be precisely of the same length. Brass points were then inserted in the upper surface of the bar, from Mr. Ramsden's standard, at the distance of forty inches from each other, the whole length of 20 feet being laid off on those points in the temperature of 54°.

The chains were measured in the Duke of Marlborough's riding-house, where the light was very convenient for the purpose, and the whole apparatus was sheltered from the wind and sun. The plank and bar were supported on five of the trestles, or tripods, belonging to the Royal Society, and the upper surface of the bar was brought into an horizontal plane by means of screws and a spirit level. The brass points on the upper surface of the bar were brought into a right line, by stretching a silver wire along the top, and pressing the bar laterally with wedges, till all the points fell under the wire. Part of the chain was then placed on rollers, which rested on narrow slips of wood fixed on the side of the plank, about five inches below, and exactly parallel to the bar; and whilst it was fastened to an adjusting-screw near one end of the plank, it was kept straight on the rollers by a weight of fifty-six pounds.

From the extremities of the 20 feet on the edge of the bar, two fine wires with plummets were suspended, which were immersed in vessels of water, the wires hanging so as nearly to touch the chain. One end of the chain being then brought under its wire, by means of the adjusting-screw, a fine point was made on the chain coinciding with the other wire. This part of the chain was then shifted, and another 20 feet measured in the same manner; and the operation continued till the length of each chain was thus

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obtained at five successive measurements. The result was, that in the temperature of $51°\frac{1}{2}$, in which the operation was preformed, the chain A was found to exceed 100 feet by 0.114 inch. and the chain B, by 0.058 inch. Now, according to the table page 88, the expansion due to 1° Fahrenheit on 100 feet of cast iron is 0.0074 inch. and that of the chain being 0.0075, their difference is 0.0001, and therefore for $2°\frac{1}{2}$ it will be 0.00025; consequently, as the points were put on the bar in the temperature of 54°, and the chains measured in $51°\frac{1}{2}$ or $2°\frac{1}{2}$ less, their lengths in the temperature of 54°, agreeing with the points on the bar, will be.

$$\begin{array}{l} \quad\ \ \text{Feet.}\quad \text{In.} \\ A = 100 + 0.11425 \\ B = 100 + 0.05825 \end{array}$$

The comparison of the chains with each other, as related in Art. 88, together with this determination of their lengths, furnish the *data* necessary for the reduction of the base on Hounslow Heath.

The wear of B, in measuring 38 chains, appeared (*vid.* Art. 88,) to be $1\frac{3}{4}$ divisions of the micrometer head $= \frac{1.75}{260} = 0.00673$ inch.: and the wear of A was 9.7 divisions $= \frac{9.7}{260} = 0.0373$ inch.

	In.	In.
Then, from the excess of A above 100 feet, namely, - -	0.11425, and of B	0.05825
subtract half the wear -	0.01865	0.00336
	0.0956	0.05489

And we get the lengths of the chains in the temperature of 54 deg. before they were used in the measurement, namely,

$$\left\{\begin{array}{l} \quad\ \ \text{Ft.}\quad\ \ \text{In.} \\ A = 100 + .0956, \text{ and} \\ B = 100 + .05489, \text{ the} \\ \text{lengths used in the re-} \\ \text{duction of the base.} \end{array}\right.$$

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Method of fixing the Iron Cannon at the Extremities of the Base on Hounslow Heath, 1791.

95. As the pipes were found in a very decayed state, and it became certain, were they suffered to remain as the *termini*, that in a few years the points marking the extremities of the base would be lost, it became necessary to re-establish them in a more permanent manner. Amongst the various means which were proposed for this purpose, that of heavy iron cannon was adopted, having been previously sanctioned with the approbation of Mr. Ramsden, and other competent judges. Two guns were therefore selected at Woolwich by order of the Master-general, from among those which had been condemned as unfit for the public service, and sent to Hampton by water.

The placing of these guns accurately being an operation of a delicate nature, and attended with some difficulty, on account of their great weight, the mode of performing it was very deliberately considered; and every precaution afterwards taken to render the operation unexceptionable. The method was as follows.

Four oaken circular pickets, of 3 inches diameter, were driven into the ground, at the distance of 10 feet each from the centre of the pipe, two of them being in the direction of the base, and the others at right angles to it. Melted lead was then run into a hollow made in the head of each picket, and afterwards filed off perfectly smooth. On the brass cup, belonging to the Royal Society, being adjusted in the pipe, silver wires were stretched from the heads of the opposite pickets, and moved till their intersection coincided with the centre of the cup; and in this position a fine line was drawn on the lead of each picket, exactly under and in the direction of the wire. This operation being performed, and the truth of it re-examined, the pipes were taken out of the ground,

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in doing which it became necessary to make an excavation of about four feet, in order to clear the circumference of the wheel. It had been at first intended to have inserted the gun so far in the ground as that its muzzle should be even with the surface of the original pipe : but upon considering that this was a matter not absolutely essential to the ascertaining of the actual length of the base by any future measurement, provided the axes of the guns were made to coincide with those of the pipes, it was determined to fix the cannon, without digging the pit to a greater depth than that of ten feet. In this position, however, it was evident, that the muzzle of the gun would rise higher than the surface of the pickets, which had been put into the ground for finding the centre ; which rendered it necessary to drive in and adjust four outer pickets, of a proper height, to determine the centre of the bore of the gun, by the intersection of another set of wires. The tops of the first set of pickets were therefore cleared, and the silver wires extended along the fine lines which had been made on the lead. A plummet was then suspended from above, and moved till it fell on the intersection of the wires. Being fixed in this position, another set of wires was stretched across the tops of the four outer pickets, till their intersection also coincided with the vertical wire of the plummet, in which position, fine lines were drawn under the wires on the top of each of the outer pickets. The truth of the operation now depending on these last pickets, they were carefully guarded by another set which surrounded each of them, and these last were again bound round with ropes, to preserve the centre pickets from any possible accident. These precautions being taken, and the pit cleared, a large stone of $2\frac{1}{2}$ feet square, and 15 inches deep, containing a circular cavity in its upper surface to receive the cascabel of the gun, was placed in the bottom of it, the centre of the hole being nearly under the intersection of the wires, as determined by a plummet. The gun was then let into the pit, and

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brought, while resting upon the stone, into a position nearly vertical, at which time a quantity of earth and stones were thrown into the pit sufficient to steady the gun. This being done, the cross wires were stretched over the outer pickets, and a pointed plummet suspended from above, having its line coinciding with the intersection of the wires, was let fall into the cylinder, in which a cross of wood that exactly fitted it was placed, whose centre corresponded with that of the bore. The gun was then moved till a dot, marking the centre of the cross, came directly under the point of the plummet; when earth and stones were rammed round the gun; care being taken to force it by that operation into its proper position, as shown by the plummet and cross. In this manner the guns were fixed at the extremities of the base; and it remains only to be observed, that to prevent the unequal settling of the earth, rammed within the pit, from moving them out of their proper positions, four beams of wood were placed in an horizontal direction, having their ends resting against the sides of the pit and the gun. It may also be added, that iron caps were screwed over the muzzles to preserve the cylinders from rain.

Particulars relative to the Commencement of the Trigonometrical Operation.

96. Having, by the re-measurement of the base on Hounslow Heath, sufficiently determined its accuracy, it became necessary, upon the approach of the following spring, to form some plan which might enable us to commence the Survey with the most advantage.

Of those which were suggested, that of proceeding immediately southward with a series of triangles seemed the most eligible, not only because, in the first instance, the execution of it would forward one great design of the business, in an early determination

of some principal points upon the sea-coast, but also because a junction of the eastern part of the series with that of the western of General Roy, would afford an early proof of what degree of accuracy had attended both operations.

To ascertain the truth of the General's work, by verifying some principal distance or distances, was an object which presented itself, not only as interesting and curious, but as highly necessary, in order to determine whether, by the result, the triangles might stand good, and become a part of the general series.

In addition to this reason, there was another which offered itself, and that was, the prospect of being able to obtain the length of a degree of longitude in an early stage of the Survey; for it had been suggested, and upon inquiry was found to be true, that Dunnose in the Isle of Wight was visible, in particular moments of fine weather, from Beachy Head on the coast of Sussex: but at the same time it was resolved, whatever preference might in future be given to those on the coast for this important operation, that at all events such observations should be made, which might determine the distance between Shooter's Hill and Nettlebed, as situations eligible for observing the directions of the meridians.

Having therefore formed an outline for the operation of the year 1792, upon the approach of spring, we explored the country, over which it was intended to carry the triangles, and visited such stations in the series of General Roy as were judged to be proper for the above purpose.

In the choice of those stations which were about to be selected, instructions had been given by his Grace the Duke of Richmond to avoid towers and high buildings, as getting an instrument on them had, by the experience which the former operation afforded, been found difficult and dangerous; such of them therefore as were thus circumstanced were avoided, and near the most proper

ones, stations were chosen on the ground. From these directions the points of junction were necessarily confined to Saint Ann's Hill, Botley Hill, and Fairlight Down, because the pipe sunk near Hundred Acre House was found to be destroyed; but this was considered immaterial in its consequence, as it would have been improper to have chosen it for a principal station, because the high ground near Warren Farm took off the view of Leith Hill.

A disadvantage however, which seemed to result from this resolution of avoiding high buildings for stations, occurred in the difficulty which offered itself of proceeding from Hanger Hill and St. Ann's Hill, with a mean distance of that side as given by General Roy; for the station chosen at the former place being on the ground, there was scarcely a possibility of erecting a staff at King's Arbour, sufficiently high to afford a view of its top from Hanger Hill: a quadrilateral therefore, similarly posited, could not be fixed on; but as a proper substitute, a station was chosen upon the elevated ground near Banstead, which was visible from St. Ann's Hill, King's Arbour, and Hanger Hill: and this, together with St. Ann's Hill and Hanger Hill, formed two triangles, which would give the distance between St. Ann's Hill and Banstead, independent of each other.

Upon our return from this expedition, in which we had selected many of the principal stations, and, by examining the face of the country, had formed some judgment of the future disposition of the triangles, preparations were made for taking the field; and the party which had been engaged in the measurement of the base, were ordered to be attached to the trigonometrical operation.

Little difficulty was found in determining upon the choice of the necessary apparatus. Lamps were constructed by Mr. Howard of Old-street, which were afterwards found to equal every thing which could be expected from them. Instead of the reflector

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being exposed to the wind, these lamps were inclosed in strong tin cases, having plates of ground glass in their fronts, which effectually prevented the bad effects of an unequal and unsteady light. In the centre of the back of each case, there were straps and semicylinders of tin, which, moving upon joints, clasped the staff to which in their use they were braced. Two of the lamps were of twelve inches diameter, and a third of twenty-two; and the last of these, prior to the use of it in the ensuing season, was lighted on Shooter's Hill, and clearly distinguished at the distance of thirty miles. Copper nozles of different sizes were likewise provided for holding the white lights.

During the measurement of the base, an observatory for the reception of the instrument was making at the Tower, as likewise two carriages, to be used in conveying them from station to station. One was made with springs for the greater safety of the instrument, which resting upon a cushion in the carriage, was sufficiently secured from any jolting upon the road.

As it was easily foreseen that upon eminences, on which it was certain the instrument would be placed, it would be hazardous to trust it in a receptacle of slight construction, great pains had been taken to make the observatory strong. It consisted of two parts, the interior one of which, or the observatory itself, was eight feet in diameter, and its floor of a circular form, and from the sides of it eight iron pillars rose to the height of seven feet, which were connected at the extremities by oaken braces. The roof was formed of eight rafters which united at the top, having their ends fastened into the heads of the iron stancheons, and were otherwise sufficiently clamped. The sides and roof were each composed of four-and-twenty frames, covered with painted canvas, any of which could be removed at pleasure; and the whole was covered with a tent formed of strong materials.

Having thus detailed, in as short a manner as possible, the heads

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of such particulars as it may be necessary the public should be acquainted with, it remains only to give some account of the improvements in our great theodolite, before we narrate the progress made in the Survey in the summer of the year 1792.

Account of the Improvements in the great Theodolite.

97. Mr. Ramsden has considerably improved this instrument, which, in other respects, is of the same dimensions and construction as that made use of by General Roy, which has already been described. The construction of the microscopes render them very superior to those of that instrument; as the means by which the image is proportioned to the required number of revolutions of the micrometer-screw, and also the mode of adjusting the wires to that image, are much facilitated: (Art. 38.) For the first, there are three prongs proceeding from the cell which holds the object-glass; these, after passing through slits in the small tube which constitutes the lower part of the microscope, are confined between two nuts which turn on this small tube, so that by turning the nuts the object-lens is moved towards, or from, the divisions on the circle, as occasion may require. To adjust the wires in the micrometer to the image; in the upper part of the body of the microscope are two nuts, one sliding within the other. To the upper end of the interior one the micrometer is fixed; and near the lower end are three prongs similar to those above mentioned, but something longer. These prongs pass through slits in the exterior tube, and are confined between nuts, in the same manner as the object-lens. This construction has many advantages over that described in Art. 38.

To obviate the necessity of the gold tongue (p. 119), besides the moveable wire in the field of the microscope, there is a second one, which may be considered as fixed, having only a small motion

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for its adjustment. When the instrument is adjusted, and the index belonging to the micrometer-screw stands at the *zero* on its circle (the moveable wire cutting one of the dots on the limb of the instrument), this fixed wire must be made to bisect the next dot; as by this means it may be perceived at any time, whether the relative position of the wire has varied.

By graduating the limb of the instrument to every ten minutes instead of fifteen, we are enabled to measure with the micrometer-screw, not only the excess of the measured angle above any of the ten minutes, but also its complement to the next division on the circle, and thereby to correct any small inequality which may happen between the divisions.

Particulars relating to the Operations of the Year 1792.

98. Although it might have been reasonably supposed, that the angles of the triangle King's Arbour, Hampton Poorhouse, and St. Ann's Hill, had been observed with sufficient accuracy in 1787, yet that this operation might not rest on *data* afforded by any former one, it was considered as proper to determine them with our own instrument.

By a reference to Art. 50, it will be found, that General Roy was obliged to elevate the instrument at the extremities of the base; for which purpose a stage of thirty-two feet high had been constructed. The same necessity existing with us, an application was made to the Royal Society for it; and in the autumn of 1791, that part of it which had been left at Dover, was brought to the Tower.

The first station to which the instrument was taken this year was Hanger Hill, because it was found upon examination, that the part of the stage which had been left at Shepperton was much damaged, and stood in need of considerable repair. It was, how-

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ever, soon fitted for use, and a new tent for the top having been provided, the half stage was erected over the pipe at St. Ann's Hill, to which from Hanger Hill the instrument was conveyed. Here, as well as at the other stations where the stage was used, a plumb-line was let fall from the axis of the instrument over the point marking the station, being sheltered from the wind by a wooden trough. In the use of the half stage, the instrument was sufficiently steady when the wind blew moderately; but from the crazy state of the lower part, it was only by watching for moments particularly calm, that satisfactory observations could be made when the whole of it was used.

The following observations will sufficiently explain the detail of this year's operations, which are given in the order of time in which they were made. By an examination of them it will be perceived, that most of the angles have been observed more than once: indeed, it was a position which we laid down upon our commencing this business, and which, as far as circumstances would admit, has since been adhered to, namely, that of observing the angles upon different arcs. When staffs were erected, which was generally the case when the stations were not more remote than fifteen miles, the angles were repeated till their truth became certain, and the same was also done, when angles were determined by the lamps; but it sometimes happened, that only one of the two white lights, which were burned at the distant stations, was seen; in which case, if the observation appeared to be made without any error, but that which an inequality in the division of the instrument might be supposed to produce, it was considered as sufficient; otherwise fresh lights were sent to the station and observed.

In the use of the white lights, it is conceived that sufficient precautions were taken, as the firing of them was always committed to particular soldiers of the party, selected from the rest

on account of their capacity and steadiness, who had instructions to place the copper nozle immediately over the point marking the station, by means of a plumb-line let fall from the bottom. In observing them with the instrument, the angle was not taken till the light was going out. But the men commonly guarded against the flame being blown greatly on one side, by erecting something to windward of the light.

In the use of the lamps also, care was taken to give them their proper direction; for when the ground about the station would not admit of the lamp being placed immediately upon it, slender staffs were erected supported by braces, and made upright, by being plumbed in directions at right angles to each other. Precautions were also used to put those staffs precisely over the points, by centering the holes in the cross-boards.

To such a part of the staff as was judged to be the most convenient, the lamp was buckled, and its direction obtained by bringing a mark in the middle of it to correspond with another on the staff, which was determined to be opposite the station, by directing a ruler to it from each side of the staff, and marking the places touched. The distance between those marks was then bisected, which gave the situation for the middle of the lamp.

In a very early stage of the business it was found, that the effects of heat and cold on the limb of the instrument were likely to produce the greatest errors; for if the canvas partitions, forming the sides of the observatory, were open to windward, streams of air passing unequally over the surface of it, would cause such sudden effects, that little dependence could be placed on any observations made with the instrument in such a state. To avoid this; it was the constant practice when the wind blew with any degree of violence, to prevent the admission of it as much as possible, by keeping up the walls of the external tent, leaving only a sufficient opening for the discovery of the lamp or light; and at other times

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when the wind blew moderately, and a greater difference appeared in the readings of the opposite microscopes, than an error in division might be supposed to produce, the walls of the external tent were entirely thrown down, and the instrument kept in an equal temperature by the admission of air on all sides.

In taking the angles, it was a general rule for some person to keep his eye at one of the microscopes, and bisect the dot, as the observer moved the limb with the finger-screw of the clamp. This precaution is very necessary when white lights are used, for should there be a mistake in reading off an angle, when several are taken from the same lamp as the permanent object, it sometimes may prove troublesome to rectify the error, without sending other white lights to the stations. We found that to be the case at Ditchling Beacon, when only one person happened to be at the instrument, and a reading was set down 10″ wrong. A similar circumstance occurred at Brightling. For these reasons, lamps are greatly preferable to white lights, when the distances are not too great.

As the instrument was sometimes found to sink on the axis, which was partly owing to wear by the constant use of it, and the screws of the centre work loosening a little by the shaking of the carriage; whenever it came to a new station, the opposite points were examined; and if it was found that the circle had fallen, which would be shewn by the runs of the micrometers, it was raised a little, and the microscopes re-adjusted.

At the different stations, after the observations had been made, large stones, from a foot and a half to two feet square, were sunk in the ground, generally two feet under the surface, having a hole of an inch square made in each of them, whose centre was the precise point of the station.

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Angles taken in the Year 1792.

99. At Hanger Hill.

Between	°	′	″	Mean. ″
Shooter's Hill and Banstead -	62	18	49.5 49.75 51.5	50.25
St. Ann's Hill and Banstead -	62	40	34.75 34.75 35.75	35
St. Ann's Hill and Hampton Poorhouse	24	39	16.5 16.5 17.75	17

At St. Ann's Hill.

King's Arbour and Hampton Poorhouse	44	18	51.5 52 53.25	52.25
Hind Head and Banstead -	90	43	33	
Banstead and Hanger Hill -	63	56	46.5 47 47.5	47
Leith Hill and Banstead -	44	3	3	
Leith Hill and Hind Head -	46	40	30.5	
Bagshot Heath and Banstead	144	39	26	
Hanger Hill and Hampton Poorhouse	25	17	40.5 41	40.75
Banstead and Hampton Poorhouse -	38	39	6 6.25	6
Shooter's Hill and Hanger Hill -	30	28	17 17	17

At King's Arbour.

Between	°	′	″	Mean. ″
St. Ann's Hill and Hampton Poorhouse	74	14	35 35.75	35.25
St. Ann's Hill and Banstead -	71	46	23 23.5	23.25

At Hampton Poorhouse.

St. Ann's Hill and King's Arbour	61	26	33.5 35.5	34.5
St. Ann's Hill and Hanger Hill -	130	3	3 3.5	3.25

At Banstead.

Shooter's Hill and Botley Hill -	57	11	36 36.25	36
St. Ann's Hill and Hanger Hill -	53	22	39.5 40	39.75
Botley Hill and Leith Hill -	108	50	47.5 48.25 51.5	49
Leith Hill and St. Ann's Hill -	77	37	33.75 37.25	35.5
King's Arbour and St. Ann's Hill -	25	15	42 42.5 42.5	42.25
Shooter's Hill and Hanger Hill -	62	57	20 24	22
Leith Hill and Shooter's Hill -	166	2	23.5 23.5	23.5

At Leith Hill.

Banstead and Botley Hill -	31	21	8 12	10
Banstead and Hind Head -	140	28	13.5 13.75	13.5

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Between	°	′	″	Mean. ″
Hind Head and Chanctonbury Ring -	72	56	49.5 51.25	50.25
Ditchling Beacon and Chanctonbury Ring	32	43	56.25 58.5	57.5
St. Ann's Hill and Hind Head -	82	8	51	
Hind Head and Crowborough Beacon -	143	57	47.5 47.75	47.5
Hind Head and Bagshot Heath -	56	37	29.5	
Shooter's Hill and Nettlebed -	86	23	24 27.5	25.75
Hind Head and Shooter's Hill -	148	28	30 32.5 33.25 33.25 33.75	32.5

At Shooter's Hill.

Botley Hill and Banstead - -	37	8	25.75	
Banstead and Blackheath - -	42	52	48.5	
Hanger Hill and Blackheath - -	11	51	1.25	
Leith Hill and Blackheath - -	48	50	6 7.5	6.75
Nettlebed and Blackheath - -	7	58	25.5	
Nettlebed and Leith Hill - -	56	48	30 32	31
St. Ann's Hill and Blackheath -	12	41	15.75 17.25	16.5

At Bagshot Heath.

St. Ann's Hill and Hind Head -	101	49	23.75	
St. Ann's Hill and Leith Hill -	53	52	13.5	
Leith Hill and Hind Head - -	47	57	7 7	7

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Between	° ′ ″	Mean. ″
Nettlebed and Leith Hill - -	168 32 12 13 16	13.75
Nettlebed and Highclere - -	60 10 26 22	24
Nettlebed and Penn Beacon -	42 50 12.25 12.75	12.5
Leith Hill and Highclere - -	131 17 22.5	

At Hind Head.

Nettlebed and Leith Hill - -	94 9 57.5 57.75	57.5
Nettlebed and Bagshot Heath -	18 44 31.25 33.25	32.25
Leith Hill and St. Ann's Hill -	51 10 38 41.5	39.75
Leith Hill and Rook's Hill -	111 57 2 4.5	3.25
Leith Hill and Butser Hill -	156 25 10.75 8.25	9.5
Leith Hill and Chanctonbury Ring	61 52 25.5	
Chanctonbury Ring and Rook's Hill	50 4 37	
Nettlebed and Highclere - -	43 8 58.5 9 0.5	59.5

At Rook's Hill.

Chanctonbury Ring and Butser Hill -	147 49 26.5	
Chanctonbury Ring and Hind Head -	82 42 45 46.5	45.75
Chanctonbury Ring and Dunnose -	137 16 48.5	
Chanctonbury Ring and Beachy Head	14 17 34	
Chanctonbury Ring and Motteston Down	153 1 1	

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At Butser Hill.

Between	°	′	″	Mean.
Rook's Hill and Hind Head -	70	25	13 14.5	″ 13.75
Rook's Hill and Dunnose - -	80	21	58	
Rook's Hill and Motteston Down -	101	7	7 9	8
Rook's Hill and Highclere - -	154	56	56 58.5	57.25
Rook's Hill and Dean Hill - -	156	34	14 *dubious.*	

At Chanctonbury Ring.

	°	′	″	Mean.
Rook's Hill and Leith Hill - -	92	23	25 25.25	25
Rook's Hill and Hind Head -	47	12	37 39.25	38
Hind Head and Leith Hill - -	45	10	46	
Rook's Hill and Ditchling Beacon -	179	8	4 8	6

Further Particulars respecting the Operations of the Year 1792.

100. Excepting the stations Nine Barrow Down, Black Down, Wingreen, Long Knoll near Maiden Bradley, Beacon Hill, Inkpin Beacon, with those about the base of verification, all the stations which constitute the series hereafter given, were selected this year.

From an opinion which we entertain, that triangles, whose sides are from 12 to about 18 miles in length, are preferable for the general purposes of a survey, to those of greater dimensions, we have endeavoured to select such stations as might constitute a series of that description. In those which were chosen to the eastward of Bagshot Heath, Hind Head, and Butser Hill, we have in

some degree succeeded; but, from local circumstances, we have not been equally fortunate with those to the westward. Instead of Dean Hill, it was hoped that the ground upon which *Farley Monument* stands, might have suited our purpose; but the wood to the west of the hill was found to be so high, that even with the whole stage, the instrument would not be sufficiently elevated. There remained, therefore, no other expedient but fixing upon Dean Hill, which is the highest spot near Farley Monument. It must be also observed, that Highclere is the only situation which affords the means of carrying on the triangles from the side Bagshot Heath and Hind Head, without forming a quadrilateral.

When the instrument was at Shooter's Hill, a staff was erected on Blackheath, for the purpose of enabling us to determine the direction of the meridian with respect to Nettlebed. This, however was not done, the weather proving too unfavourable; but as some of the stations were referred to this staff, it may be proper to observe, that on account of its being so near Shooter's Hill, a small portfire was placed in a groove cut in it, which afforded the means of taking an angle very exactly, as the light had the appearance of a bright point.

The interior stations which were selected for the use of the small instrument, were Bow Hill, near Rook's Hill; Portsdown Common, on the road to Portsmouth; and Sleep Down, near Steyning. To the first and last of these the instrument was taken, for the purpose of fixing such objects as could not be intersected from the principal station. The points on the coast were particularly wanted, for the construction of some maps which were making for the use of the Board of Ordnance. Those places so fixed will be given hereafter; but it must be observed, that few opportunities were lost of searching for church towers, and other objects whose situations were to be determined. That the bearings of those might be taken with precision, the observations were

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made either in the morning or evening, when the air was free from vapour, and without that quivering motion, which, in summer, it generally has in the middle of the day.

Improvement in the Axis of the great Theodolite; and the Progress of the Survey in the Year 1793.

101. Towards the conclusion of the last year's operation, it was found that the axis of the instrument, by the frequent use of it, was considerably worn, and which was, perhaps, increased by the motion of the carriage, as the arch could not be clamped with tightness sufficient to prevent the circle from moving within the limits of the bell-metal arms, and the upright part of the travelling case. The consequence was, that it sometimes became necessary to let the circle lower by means of the screws, and as it was found to be exceedingly difficult to turn them equally, and by a quantity which was just sufficient, an application was made to Mr. Ramsden to apply something to the axis, which might enable us to adjust the circle with greater ease and accuracy. Accordingly, upon the party arriving in town, the instrument was taken to his house, and left there for the winter, during which he made the desired alteration.

The progress made in the Survey during the last season, determined the extent of the business for this year: and it was then imagined, that with good weather, we might be enabled to join the triangles to the eastward with those of General Roy, and likewise observe the remaining angles in the series, having first made the necessary observations at Dunnose and Beachy Head for obtaining the directions of the meridians. It had also been foreseen, that it would soon become necessary to select some spot for the measurement of a new base, not only to verify the triangles remote from Hounslow Heath, but likewise to determine the sides of those

which might be hereafter projected for the survey of the West of England. The situation which we had looked forward to, as being the only one which would afford a base line of sufficient extent, was Sedgemoor in Somersetshire, not having then imagined that any place could be found fit for the purpose to the eastward of that situation.

After maturely deliberating upon the steps to be taken for this necessary business, we were of opinion, that Sedgemoor, was rather too far westward for a base, which was intended to be applied as a test to the sides of the great triangles now constituted. Inquiry was therefore made after a spot which might be less exceptionable; and as information was obtained that Longham Common, near Poole in Dorsetshire, was likely to afford such a base, we examined it in the January of this year; but not finding it fit for the purpose, we proceeded to Salisbury Plain, where we found that a base line of nearly seven miles might be measured without much difficulty, between Beacon Hill, near Amesbury, and the Castle of Old Sarum. With respect to the nature of the ground, as any observations concerning it will be introduced with more advantage when we treat of the particulars of the measurement, it will be only necessary to observe, that prior to determining upon the possibility of measuring it with the necessary accuracy, we considered of the errors which would be likely to creep in from the many hypothenuses which the base would consist of, and from other circumstances which the ground from its inequality might be supposed to produce.

As the principal object of this year's business was, to determine the directions of the meridians, the party left London for the Isle of Wight early in the month of March, that it might arrive at Dunnose in proper time for making the required observations. The instrument, however, was first taken to Motteston Down, for the purpose of intersecting many places whose bearings had been

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last year taken when the instrument was at Rook's Hill, and which were now wanted by the surveyors of the Ordnance. This station had been selected for that purpose, and was never intended to become a principal one in the series; but when the instrument was on the spot, it was considered as proper that some observations should be made to the stations which were at that time chosen. For this reason, when the time for observing the star approached, and most of the lights had been fired without our having seen them, it was not considered of consequence to remain there any longer, and the instrument was therefore taken to Dunnose.

A small staff, of about three inches diameter, was erected on Brading Down, which is about six miles from the station, for the purpose of referring the star to it; a small lamp of six inches diameter, constructed upon the same plan as the large ones, being when made use of, buckled to the bottom of the staff.

As the best method of obtaining the direction of the meridian, is by observing the star upon each side of the pole, whence the double azimuth is nearly obtained without any correction for the star's apparent motions, every opportunity was watched, of observing it at the times of its greatest apparent eastern and western elongations. But in the unsettled season of the month of April, when almost every wind brought a fog over the station, many days elapsed without our seeing either the star or staff; and it was on that account we continued so long at Dunnose.

As the truth of the deductions must entirely depend on the accurate determination of the directions of the meridians, the greatest care was taken in making the observations. An hour, and generally more, before the star came to its greatest elongation, the observers repaired to the tent for the purpose of getting the instrument ready. The method of adjusting it, was first by levelling it in the common way with the spirit level which hangs on the brass pins; and afterwards, by that which applies to the axis

of the transit. The criterion which determined the instrument to be properly adjusted, was the bubble of the latter level remaining immoveable between its indexes, while the circle was turned round the axis.

As the star, four minutes either before or after its greatest elongation, moves only about a second in azimuth, the time was shown sufficiently near, by a good pocket watch, which was regulated as often as opportunities offered. When the star was supposed to be at its greatest elongation, the observer, if at night, brought it upon the cross wires, and bisected it, leaving equal portions of light on each side of the cross: but if it was in the day, when the star appeared like a point, the telescope was moved in the vertical till it came near the vanishing point of the cross. At either of these times, when the observer was satisfied of the star being properly bisected, or brought into the vanishing point formed by the wires, another person who had kept his eye at the microscope, bisected the dot. The transit was then taken off, and the instrument being turned half round, and the telescope replaced, the star was observed again. This precaution was taken to obviate the errors which might arise, from the arms of the instrument being out of the parallel with the plane of the circle, owing to any imperfections in the positions of the Ys, on which the transit rested. It was, however, seldom found, that a greater difference subsisted between the readings of the opposite microscopes, than what might be supposed to be the consequence of a shake in the centre, or errors in division. A mean of the readings was always taken. It must be also mentioned, that out of twenty, three and four inch white lights, which were fired at Beachy Head, only three of them were seen: but the angle between that place and the staff on Brading Down was considered, from the near agreement in the observations, to be determined with the necessary accuracy.

After the business was finished at Dunnose, the instrument was

taken to Chanctonbury Ring, and Ditchling Beacon; and from the latter place to Beachy Head, in order to observe the direction of the meridian; but after placing a staff upon the high ground above Jevington, we were obliged to defer the attempt, as it was found, that owing to the effects of heat, the air was not sufficiently steady for the staff to be seen distinctly, when the star came to its greatest elongation in the day time, if the sun shone out. We therefore left Beachy Head, and proceeded to the following stations, *viz.* Fairlight Down, Brightling, Crowborough Beacon, and Botley Hill; from which latter place we returned in June to Beachy Head, and observed the direction of the meridian.

From this station, the party went to Dean Hill, and thence to Salisbury Plain, for the purpose of fixing on the extremities of the new base. This being done, the instrument was taken to Old Sarum, Four Mile Stone, Beacon Hill, Thorney Down, and Highclere, where the operations of this year terminated. But it must be observed, that owing to a strain which the clamp of the instrument sustained when at Thorney Down, no dependance could be placed on the observations which were made at Highclere. Upon this being discovered, and the season too far advanced to permit of any business being done after the instrument might be repaired, the party returned to London.

Angles taken in the Year 1793.

102. At Motteston Down.

Between	° ′ ″	Mean.
Nine Barrow Down and Dunnose -	159 51 2.5 5	3.75″
Butser Hill and Dunnose - -	64 41 2	
Rook's Hill and Dunnose - -	44 57 46 *dubious.*	

At Dunnose.

Between	° ′ ″	Mean.
Dean Hill and Brading staff -	55 58 38.5 38.75	″ 38.5
Motteston Down and Brading staff -	94 49 19	
Nine Barrow Down and Brading staff	109 11 3.5 8	5.75
Butser Hill and Brading staff -	0 15 31.5	
Rook's Hill and Brading staff -	24 28 42.5 45.5	44
Chanctonbury Ring and Brading staff	40 11 44	
Beachy Head and Brading staff -	60 42 40 42 42.25	41.5
Pole star and Brading staff, Apr. 21, aftern.	24 4 21.25	
22, aftern.	24 4 22	
28, aftern.	24 4 23	
29, morn.	18 24 0	
May 5, aftern.	24 4 27.25	
12, aftern.	24 4 29.5	
13, morn.	18 23 53.25	

At Chanctonbury Ring.

Beachy Head and Shoreham staff -	32 49 48.5 49	
Dunnose and Shoreham staff -	98 9 48.75 49.75	49.25
Rook's Hill and Shoreham staff -	125 10 2.25	

At Ditchling Beacon.

Beachy Head and Lewes staff -	20 52 0.75	
Crowborough Beacon and Lewes staff	57 8 36	
Leith Hill and Lewes staff -	135 27 1.75 4	3

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Between	°	′	″	Mean. ″
Brightling and Lewes staff -	25	40	18.25	
Chanctonbury Ring and Lewes staff	164	1	31 32.5 33.5	32.25

At Fairlight Down.

Bightling and Beachy Head -	59	33	1.5 2	1.75

At Brightling.

Fairlight Down and Beachy Head -	80	44	17.5 21	19.25
Crowborough Beacon and Beachy Head	102	58	14 17	15.5
Ditchling and Beachy Head - -	59	29	13.5 14.5	14

At Crowborough Beacon.

Brightling and Leith Hill - -	168	27	20.5 22	21.25
Brightling and Ditchling Beacon -	105	2	43 44.75	44
Brightling and Botley Hill -	145	20	27	

At Botley Hill.

Banstead and Wrotham Hill -	152	57	2.5 6	4.25
Banstead and Shooter's Hill -	85	39	58.5	
Banstead and Crowborough Beacon	129	23	3.5	
Crowborough Beacon and Leith Hill	89	35	1	

At Beachy Head.

Brightling and Jevington staff -	46	59	33.25 34.75	34

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Between	° ′ ″	Mean. ″
Fairlight Down and Jevington staff -	86 42 12 14	13
Rook's Hill and Jevington staff -	48 39 59	
Chanctonbury Ring and Jevington staff	40 57 21 23	22
Dunnose and Jevington staff - -	69 26 51.25 52 52 53.25	52
Ditchling Beacon and Brightling -	73 58 25 28	26.5
Pole star and Jevington staff, Jul. 15 at night	30 19 54.5	
16 night	30 19 57 5	
26 morn.	24 38 19	
30 night	30 19 50.5	
Aug. 1 morn.	24 38 20.25	
1 night	30 19 49.5	
2 night	30 19 50.25	
3 morn.	24 38 23.5	
* 11 night	30 19 47.25	

At Dean Hill.

Beacon Hill and Highclere -	50 18 47.5 47.5	47.5
Beacon Hill and Wingreen - -	82 56 47 50	48.5
Beacon Hill and Dunnose - -	160 46 8.5	
Beacon Hill and Nine Barrow Down	134 23 32.25 32.75	32.5
Beacon Hill and Motteston Down	174 34 56.5 58.5	57.5

* Many observations of the star at this station, and also at Dunnose, are rejected on account of their being made under unfavourable circumstances.

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Between	°	′	″	Mean. ″
Beacon Hill and Four Mile Stone -	39	29	1.5 5	3.25
Beacon Hill and Butser Hill -	112	41	36 36.5 38	36.75
At Old Sarum.				
Beacon Hill and Four Mile Stone -	85	58	21.5 21.75 22.25 23.75	22.5
Beacon Hill and Thorney Down -	48	26	3 4.25 6.5	4.5
At Four Mile Stone.				
Beacon Hill and Oid Sarum -	70	1	45.75 47.25 48.25 49	47.5
Beacon Hill and Dean Hill - -	72	4	46.5 49.25	48
At Beacon Hill.				
Old Sarum and Four Mile Stone -	23	59	50.25 52.25	51.75
Old Sarum and Thorney Down -	33	33	23.75 24 26	24.5
Dean Hill and Four Mile Stone -	68	26	8.5 10.25 11	10
Dean Hill and Highclere -	102	45	23.5	
Thorney Down and Highclere -	113	38	13.75 16.75	15.25

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At Thorney Down.

Between	° ′ ″	Mean.
Beacon Hill and Highclere -	53 22 28.5 30	″ 29.25
Beacon Hill and Old Sarum -	98 0 29.25 32.5	31

At Highclere.

Dean Hill and Beacon Hill -	26 55 53 54	53.5

Particulars relating to the Operations of the Year 1794.

103. The party this year took the field the fourth of March, and proceeded from London to the Isle of Purbeck, taking Butser Hill in its way. In the observations of the year 1792, the angle at that station, between Rook's Hill and Dean Hill, is noted to be dubious. The reason which induced us to be of that opinion was, that the telescope, by some accident, was thought to have been moved after the observation of the light, and just at the time when the angle was about to be read off. As the season was then far advanced, and four lights had been fired, without our having seen more than one of them, it was determined to leave the final observation of that angle till this year. Accordingly upon our arrival at Butser Hill this second time, a lamp was sent to each of the stations, and the angle repeatedly taken, as given in the following article. The party from thence proceeded to Nine Barrow Down in the Island of Purbeck.

The reason of the business commencing so early in the season, arose from the necessity of beginning the measurement of the base on Salisbury Plain, towards the latter end of June, that it might be finished before the year should be far advanced, when the cultivated ground a mile to the northward of Old Sarum would

be ploughed. It was also necessary that the angles at Wingreen and Highclere should be observed.

On account of the magnitude of the 24th and 27th triangles, the instrument was kept at the station in the Island of Purbeck till the angles between Dean Hill and the stations in the Isle of Wight were determined very accurately. It was, therefore, not till a month after the two first lights were fired, that as many observations were made as we deemed to be sufficient.

As it will answer our purpose better, to give an account of the stations which were chosen this year, for the further prosecution of the Survey, in another part of this work; it remains only to be observed, that from Nine Barrow Down the instrument was taken to Black Down near Dorchester, and thence to Wingreen, Highclere, and Beacon Hill; the observations which were made this year being concluded at the latter place in the beginning of June. It may, however, be mentioned, that in addition to the interior stations chosen in the year 1792, for the future use of the small instrument, three others were selected in this and the preceding season, namely, *Ramsden Hill*, near Christchurch; *Thorness* in the Isle of Wight; and *Stockbridge Hill.*

Angles taken in the Year 1794.

104. At Butser Hill.

Between	°	'	"	Mean. "
Rook's Hill and Dean Hill -	156	34	19.75	20
			20.5	
			19.75	

At Nine Barrow Down.

	°	'	"	Mean. "
Dean Hill and Wingreen - -	39	34	27.75	28.75
			30.25	
			28.5	
Dean Hill and Motteston Down -	56	9	55	55.25
			55.5	

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Between	°	′	″	Mean.
Dean Hill and Dunnose -	61	57	20.75	″ 20
			20	
			19	
Lulworth and Bull Barrow -	52	47	34.25	33
			32	
Dean Hill and Bull Barrow - -	71	31	55.5	54.25
			56.5	
			53	
			52	
Black Down and Bull Barrow -	38	58	19	19.25
			19.5	
At Black Down.				
Charton Common and Bull Barrow -	125	32	33.25	33.25
			33.25	
Bull Barrow and Nine Barrow Down	56	30	18.25	18.75
			19.5	
			18	
			19.75	
Bull Barrow and Lulworth -	65	35	40.5	42.5
			41	
			42.5	
			45.5	
Lulworth and station above Chesil, in Portland - -	43	3	16.25	19.75
			19.75	
			19.75	
			21.75	
			21	
Lulworth and station near Portland Light House -	52	43	49.25	51.75
			51.25	
			53.25	
			53.25	
Pilsden Hill and Mintern - -	66	51	19.25	21.75
			21	
			24.75	

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Between	°	′	″	Mean. ″
Mintern and Bull Barrow - -	31	25	56.75 57 59	57.5

At Wingreen.

	°	′	″	Mean. ″
Beacon Hill and Dean Hill - -	30	13	23.75 22 23.5	23
Dean Hill and Nine Barrow Down	88	58	45.25 47.75	46.5
Dean Hill and Bull Barrow -	143	28	21 22 23.75 25.25	23
Bull Barrow and Bradley Knoll -	96	20	39.25 36.5 33.25 38.25 37.25	37
Bradley Knoll and Beacon Hill -	89	57	40.25 37.75 37.75 37.25 35	37.75

At Highclere.

	°	′	″	Mean. ″
Butser Hill and Dean Hill - -	69	8	33.5 36.75 35	35
Dean Hill and Beacon Hill - -	26	55	50.5 52.25	51.5
Thorney Down and Beacon Hill -	12	59	10.5 9.25	10
Beacon Hill and Inkpin Beacon - -	56	0	29 30.25 30	29.75

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Between	°	′	″	Mean.
Beacon Hill and White Horse Hill (near Wantage) - - -	90	28	20 21	″ 20.5
Nuffield and Bagshot Heath -	46	10	17.5 19.5	18.5
Bagshot Heath and Hind Head -	34	46	14.75 15.75 16.75	15.75
Butser Hill and Hind Head - -	29	12	22 22.25	22

At Beacon Hill.

Dean Hill and Wingreen - -	66	49	52.25 51.75	52
Wingreen and Bradley Knoll -	32	11	44.75 44.25 43.5 40.75	43.25
Inkpin Beacon and Dean Hill -	120	28	2.25 1.25 3	2
Wingreen and St. Ann's Hill (near Devizes) - - - -	106	27	9 8 7	8

Situations of the Stations.

105. *Hanger Hill.* The station on this Hill is in the field to the eastward of the Tower, and within 13 feet of the eastern hedge. The Tower bears due west of the station.

Shooter's Hill. The station is in the north-west corner of the field, opposite to the Bull Tavern.

Banstead. The station is in a field belonging to Warren Farm, near the road leading to Ryegate. It is 14 feet north of the

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hedge, and may be easily found, as Leith Hill and an opening between two rows of trees on Banstead Common, are in a line with the station.

Leith Hill in Surrey. The station is 32 feet from the north-east corner of the Tower, and in that direction from it.

Crowborough Beacon, Sussex. The station is about 600 feet due south of the spot on which the beacon was formerly erected.

Brightling, Sussex. The station is about 70 feet south-west of the gate belonging to the field in which stands Brightling Windmill.

Beachy Head. Twelve yards south-west of the Signal-house. The muzzle of the gun is above the surface of the ground.

Ditchling Beacon, Sussex. The station is in the middle of a small rising, which has the appearance of having once been a Barrow.

Chanctonbury Ring, Sussex. This place is near Steyning; and the station is situated 50 feet from the ditch on the west side of the Ring.

Rook's Hill, near Goodwood, Sussex. The station is east of the Trundle, and near it.

Butser Hill, Hampshire. There is no precise way of pointing out the spot on which the instrument was placed: the general situation of it, however, may be known: it is on the middle of the hill, which is itself near, and to the northward of the Fifty-four Mile-stone on the Portsmouth road.

Dunnose, Isle of Wight. The station is 87 feet northward of Shanklin Beacon Pole: the muzzle of the gun is above the surface of the ground.

Motteston Down, Isle of Wight. The station is on the west Barrow.

Nine Barrow Down, Isle of Purbeck. The station is on the highest of the *Nine Barrows.*

Black Down in Dorsetshire. The station is 23 feet west of the North Barrow. Black Down is six miles from Dorchester, and near the village of Winterbourn.

Bull Barrow Hill, near Milton Abbey in Dorsetshire. The station is on the Barrow.

Wingreen, Dorsetshire. The hill so named, is four miles east of Shaftesbury, and the station is about 80 feet south-west of the Ring, or clump of trees.

Beacon Hill, about two miles from Amesbury, near the Andover road, Wiltshire. The muzzle of the gun is 8 or 9 inches above the ground.

Old Sarum. The station is south-east of the Two Mile-stone, and near it. The muzzle of the gun is 7 or 8 inches above the ground.

Four Mile-stone, Wiltshire. The station is in the field west of the Four Mile-stone on the Devizes road, leading from Salisbury. It is on the rising which is in the middle of the field.

Thorney Down, Wiltshire. The Down is near Winterbourn, and the station to the north of the wood.

Dean Hill, Hampshire. This place is near the village of Dean, and about 6 miles east of Salisbury: the station is in the north-west corner of a field belonging to Mr. Haliday.

Inkpin Beacon, Wiltshire. This place is above the village of Inkpin, and the station is in the centre of the small field circumscribed by a ditch and parapet of an ancient fortification.

Highclere, Wiltshire. The station is in the centre of the Ring on Beacon Hill, about half a mile south-east of Highclere.

Bagshot Heath. The station is on the brow of an eminence two miles north of the Golden Farmer, and directly west of the north corner of Bagshot Park.

Hind Head, Surrey. The station is near the Gibbet, being about 22 feet north-west of it.

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The situations of those stations which are common to this operation and that of General Roy, are not described, the same being done in Art. 55.

As it is probable that some individual will avail himself of the particulars given in this performance, by forming more correct maps of the countles over which the triangles have been carried, and who consequently may wish to visit certain of the stations, it is proper to observe, that small stakes are placed over the stones sunk in the ground, having their tops projecting a little above it. For some years there will be little difficulty in finding the stations, as the spots are well known to the neighbouring inhabitants.

Measurement of the Base of Verification on Salisbury Plain with an Hundred Feet Steel Chain, in the Summer of the Year 1794.

Apparatus provided for the Measurement, and the Method of using particular Articles of it.

106. The apparatus with which this base was measured arrived at Beacon Hill the 25th of June, and consisted of the two steel chains, the trestles belonging to the Royal Society, and the coffers which were used on Hounslow Heath, together with the pickets, iron-heads, and a few other articles, which in the beginning of this year had been made at the Tower. As it was foreseen that the truth of this measurement would, in a great degree, depend on the accurate reduction of the several hypothenuses to the plane of the horizon, an application was made to Mr. Ramsden in the foregoing winter, to consider of some means by which their inclinations might be obtained. He therefore applied an arch S to the side of the transit telescope, as exhibited in Pl. XVII. which he divided into half degrees; and opposite to this he placed a

microscope T, with a moveable wire in its focus, by means of which, and the micrometer of the telescope, an angle could be taken.

On the first convenient opportunity after the arrival of the apparatus, we determined the value of any number of revolutions of the micrometer-screw in parts of a degree, by the following method.

At the distance of an hundred feet from the transit, a picket was set up, on which a dot was made with chalk, and the instrument being adjusted, was moved by the finger-screw till the edge of the micrometer-wire touched some prominent part of that mark. The wire in the focus of the microscope was then made to bisect a dot upon the arch, and the telescope moved in the vertical till the next dot was bisected, by which the instrument had described half a degree upon its axis, and the micrometer-wire was afterwards moved till it touched the same part of the chalk mark, the revolutions being counted, which were consequently equal to thirty minutes. This operation was repeatedly tried, with a picket placed from one to six hundred feet successively from the telescope, the runs of the micrometer-screw being in each case nearly the same, as indeed they ought to be according to theory.

The number of revolutions equal to 30′ was found, from a mean of those trials, to be $12\frac{10}{100}$.

Having determined this, the chains A and B were compared with each other, when they were found to have the same difference of lengths as when measured by Mr. Ramsden.

For the purpose of tracing out the line of the base, as Beacon Hill had a commanding view of almost the whole of it, the instrument was kept in the tent after the observations were finished: and at different times, when the air was sufficiently steady for the purpose, many points in the true direction were found by bisecting the staff erected at Old Sarum, and moving the transit in the vertical, whilst a person placed a camp-colour in the proper situation

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on the ground, by means of signals which were made at Beacon Hill.

As it appeared, when this spot was first selected for the measurement, that in the course of it there would be frequent necessity for changing the directions of the hypothenuses, a brass bar, of a prismatic form, had been provided, by means of which, and a plumb-line, a new direction was easily taken. The method of using them was as follows.

A picket was driven into the ground close to the handle of the chain, having its top eight or ten inches above the place where the preceding hypothenuse was to terminate, one of the register-heads, with the bar, being screwed on it: the chain was then stretched, and the silver wire, or plumb-line, made to pass through the handle, whilst the slider was moved till the wire came upon the dart, marking by this means, the termination of the hypothenuse. In order, however, to give a more perfect idea of this matter, a figure is given in Pl. XIX. where B is the bar, with the wire falling through the handle of the chain, one half of it being left out, for the purpose of showing its coincidence with the arrow on the handle.

The experience which we had obtained in the measurement of the base on Hounslow Heath, led us to discover, that some of the methods we made use of to execute particular parts of it, might have been improved. One of them was, the means by which the heads of the pickets were placed in the plane of the base, which frequently was the cause of the planes of the register-heads being out of the direction of the hypothenuses. In this operation, however, the bottoms, as well as the tops of them, were placed in the true vertical by means of the transit-instrument, and therefore it was not difficult to bring the planes of their tops into the required position.

For the purpose of using the transit as a boning telescope, as

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well as an instrument for taking the angles of elevation or depression, Mr. Ramsden provided two mahogany boards, one of which was fastened to the register-head, and the other (furnished with levelling screws) rested upon it, the transit-instrument being placed on the latter.

The level belonging to the transit was then hung on the arms; and if the axis proved to be horizontal, which it would be if the brass heads were rightly placed, the instrument required no farther adjustment; but if that did not prove to be the case, the axis was made parallel to the horizon by the screws of the levelling-board, which were turned in contrary directions, having in the first instance been worked till within half the limits of their adjustment. By this means the axis was kept at a constant height from the brass heads.

A board with a cross piece, whose upper edge from the bottom of it was equal to the distance of the axis of the instrument from the head of the picket, was placed on another picket which had been driven till its head was at a convenient height in the plane of the base, and the transit moved in the vertical till the edge of the wire in the centre of the glass, coincided with that of the cross piece. The rest of the pickets in that hypothenuse were then driven into the ground, till their tops were in the same right line, as discovered by the application of this board to their heads.

The method of determining the angles which the measured lines made with the plane of the horizon was as follows.

After the hypothenuse was measured, the transit-instrument with its boards were placed on the picket, and the levelling-screws moved as before described, if the axis did not happen to be horizontal. The cross board, upon which a black line was drawn, whose breadth was about twice the apparent thickness of the micrometer-wire, and its distance from the bottom of it equal to that of the axis of the instrument from the register-head, was placed

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on another picket in the hypothenuse, having the brass head which had been before fixed on it still remaining. The telescope was then made horizontal, the index of the micrometer being placed to the *zero* on its circle, and the wire of the microscope set to bisect that dot on the arch which was nearest to the centre of the field. After this, the telescope was moved in the vertical by the finger-screw, till another dot was bisected, at the same time that the line upon the cross board appeared in the glass, by which the angle that the instrument had described on its axis, was measured in half degrees. The remaining part of the angle, or rather the fractional part of an half degree, was measured with the micrometer, the wire of which was brought from the centre of the glass to bisect the black line, and was either added to, or subtracted from, the former quantity, as the angle described by the telescope fell short of, or exceeded, that formed by the hypothenuse and the plane of the horizon.

By this method, all the angles of elevation and depression were taken. And we consider it as probable that they are within a quarter of a minute of the truth; since the instrument was capable of being used with great accuracy, the arch having been divided by one of Mr. Ramsden's best workmen, and the value of one, or any number of revolutions of the micrometer-screw, had been accurately obtained. If, therefore, any considerable errors have taken place in this part of the operation, they must have arisen from the axis of the transit-instrument and the line on the cross board not being of the same height from the brass heads on which they were placed: but we think there is almost a certainty that this difference was confined to such limits as will not introduce any errors of consequence; for even supposing the register-heads were placed on the pickets so unskilfully that it became necessary to turn the screws on the levelling-board as much as they were capable of, whilst the third remained unmoved, in order to adjust

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the transit, the error introduced on that account would be only half a minute, even though the hypothenuse should consist of but one chain, and be inclined to the horizon eight degrees. We therefore think ourselves justified in the opinion which we entertain of these angles being determined with sufficient accuracy; since, if an error of one minute had taken place in the inclination of each hypothenuse, and those errors lay all one way, the length of the base, as hereafter given, would only be varied three inches by that circumstance.

It may, perhaps, be imagined that some small errors have arisen from the handle of the chain not lying flat upon the brass heads when the new directions have been commenced. To obviate this, precautions were always taken to drive the pickets at the termination of the hypothenuses in such a manner, that the arrow on the handle could be made to coincide with one of the divisions near the end of the brass scale, by which any error arising from their not being exactly in the same vertical plane, was rendered so trifling as not to be worth notice.

Having now related, with as much conciseness as the subject will admit, the methods which were adopted for the execution of the most essential parts of this operation, there remain only a few other particulars to be related before we give the reduction of the base.

After as many points as were judged necessary had been fixed in the true direction, by the means heretofore described, and the chains compared with each other, the mensuration was begun, and continued without much interruption for seven weeks, when it was finished with that part of the 366th chain which terminated its apparent length.

The method taken to mark this last mentioned chain, was by cutting a small hole in the bottom of the coffer, through which a plumb-line was made to pass, the point of the plummet being

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brought over the end of the base, and the chain moved till it touched the wire; a slight scratch was then made with a file at the point of contact.

On the first favourable opportunity, subsequent to this conclusion of the measurement, the chains A and B were compared with each other, when it was found that the wear of the former, by the constant use of it, was only one division of the micrometer head, or $\frac{1}{260}$ th of an inch. The smallness of this quantity in the measurement of a base of such great length, was doubtless owing to the pivots, and pivot holes of the joints being smoothed, and as it were polished, in the operation on Hounslow Heath; and it may also be adduced as some proof, that the joints had not rusted while the chains remained in the Tower; but to prevent this, care had been taken to deposite them in a dry place, being afterwards frequently examined and oiled.

Thus concluded the measurement of this base, in which it is certain that great pains were taken to produce an accurate result; and we are not without hopes, that the many obstacles which offered themselves have been surmounted with success; but this is left to the decision of the candid and intelligent reader.

The following table contains the particulars of this operation. The first column showing the number of hypothenuses; the second, that of the chains in each hypothenuse; the third, the observed angles of elevation or depression given to the nearest 10″; the fourth and fifth, the perpendiculars answering to the elevations and depressions; the sixth, the reduction of the hypothenuses to the horizontal lines, or the versed sines of the elevations and depressions to the hypothenuses as *radii;* the seventh and eighth, the perpendicular distance between the termination and beginning of any two hypothenuses when a new direction was commenced above or below.

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107. *Table of the Measurement of the Base of Verification.*

Hypothenuses. No.	Hypothenuses. Chs.	Angles of Elev. or Depr.	Perpendiculars. Elevation.	Perpendiculars. Depression.	Reduction.	Below.	Above.
		° ′ ″	Feet.	Feet.	Feet.	Inches.	Inches.
1	1	7 52 30		13.7012	0.9431		
2	1	11 31 40		19.9843	2.0172		
3	1	10 5 0		17.5080	1.5446		
4	1	7 25 20		12.9180	0.8379		
5	1	5 41 50		9 9272	0.4940		
6	7	4 49 30		58.8788	2.4806		
7	6	4 18 40		45.1033	1.6977		
8	3	3 48 30		19.9257	0.6625	31.5	
9	3	3 13 0		16.8336	0.4727	21.5	
10	1	0 9 0		0.2618	0.0003		
11	1	2 27 30	4.2893		0.0920		
12	1	0 58 30	1.7016		0.0145		
13	3	0 5 0	0.4363		0.0003		
14	6	0 34 10		5.9631	0.0293	11.5	
15	1	3 9 10	5.4999		0.1514		
16	2	1 25 20	4.9640		0.0616		
17	2	0 24 10	1.4059		0.0049		
18	5	0 8 10		1.1878	0.0014		
19	4	0 49 10	5.7206		0.0409		
20	4	0 10 50	1.2605		0.0020		
21	3	1 19 20		6.9225	0.0799	7.0	
22	7	1 38 20		20.0201	0.2864		
23	5	1 33 40		13.6216	0.1856	5.5	
24	6	1 18 20		13.6706	0.1558	14.5	
25	1	1 34 30		2.7485	0.0378		
26	9	1 15 0		19 6334	0.2142		
27	6	1 0 50		10.6169	0.0939		
28	2	0 5 40	0.3297		0.0003		
29	3	0 49 50	4.3486		0.0315		
30	5	0 15 10	2.2059		0.0049		
31	3	0 18 20		1.5999	0.0043		
32	5	0 8 50	1.2848		0.0017	18.5	
33	3	0 53 30	4.6686		0.0363		
34	8	0 8 50	2.0556		0.0026		
35	10	0 45 10	13.1381		0.0863		
36	4	0 14 0		1.6290	0.0033		
37	5	0 52 0		7.5628	0.0572		
38	2	1 40 10		5.8266	0.0849		
39	7	0 35 30		7.2284	0.0373		
40	4	1 3 10		7.3494	0.0675		
41	3	0 33 50		2.9525	0.0145	19.25	
42	1	0 54 10	1.5756		0.0124		
43	2	1 37 0	5.6425		0.0796		
44	3	0 8 40		0.7563	0.0009		
45	3	0 50 10		4.3777	0.0319		
46	4	0 55 50		6.4962	0.0529	20.0	
47	11	0 31 40		10.1325	0.0467		

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Hypothenuses. No.	Hypothenuses. Chs.	Angles of Elev. or Depr.	Perpendiculars. Elevation.	Perpendiculars. Depression.	Reduction.	Below.	Above.
		° ′ ″	Feet.	Feet.	Feet.	Inches.	Inches.
48	3	0 45 30		3.9705	0.0263		
49	3	1 18 40		6.8644	0.0785		
50	2	1 58 50		6.9121	0.1195		
51	2	3 49 30		13.3418	0.4455		
52	2	3 24 20		11.8806	0.3532	29.25	
53	2	3 20 50	11.6774		0.3412		
54	2	2 31 10	8.7917		0.1933		
55	2	1 7 0	3.8976		0.0380		24.5
56	7	0 25 40		5.2262	0.0195		
57	5	0 55 40		8.0960	0.0656		
58	2	3 2 50		10.6318	0.2828		
59	2	5 34 10		19.4104	0.9441		
60	1	2 4 50		3.6305	0.0659		
61	4	0 34 10	3.9754		0.0198	8.5	
62	2	0 51 40		3 0057	0.0225		
63	3	1 21 40		7.1261	0.0847	33.0	
64	9	3 4 30	48.2788		1.2958		29.0
65	4	2 16 10	15 8396		0.3137		28.75
66	6	0 14 20	2.5016		0.0052		
67	6	1 19 10		13.8160	0.1591		
68	3	1 56 30		10.1646	0.1722		
69	3	0 25 10	2.1962		0.0080		
70	2	0 51 10	2.9766		0.0222		
71	5	0 48 20		7.0296	0.[illegible]494		
72	4	0 35 40	4.1499		0.0215		
73	4	1 30 0	10.4708		0.1371		
74	4	1 5 20	7.6014		0.0722		1[illegible].5
75	4	0 38 50		4.5184	0.0255		6.0
76	5	1 56 30		16.9410	0.2871	42.0	
77	12	0 34 50		12.1579	0.0616		
78	7	1 8 50		14.0150	0.1403		
79	9	1 37 40		25.5656	0.3632	12.0	
80	3	1 49 40		9.5686	0.1526		
81	4	0 1 0		.1163			
82	7	1 25 0		17.3061	0.2140		
83	4	1 46 40		12.4092	0.1925		
84	7	0 41 50		8.5180	0.0518		
85	5	0 46 20	6.7387		0.0454		
86	3	0 20 40	1.8035		0.0054		12.0
87	3	1 34 20		8.2311	0.11[illegible]9		
88	3	3 7 10	16.3253		0.44[illegible]5		
89	5	1 2 20	9 0655		0.0822		
90	6	0 4 20		0.7563	0.0005		
91	3	1 34 50		8.2747	0.1141	4.0	
92	3	0 21 30	1.8762		0.0059		
			218.6937	634.8222	20.9158	278.0	117.25

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Reduction of the Base measured on Salisbury Plain, to the Temperature of 62°.

	Feet.
108. The overplus of the 366th chain was measured by Mr. Ramsden, and found to be 9.939 feet; therefore the apparent length of the base was -	36590.061
By the measurement in the Duke of Marlborough's riding-house, the chain A was found to exceed 100 feet in the temperature of 54°, by 0.11425 inches; to which adding half the wear, namely, $\frac{1}{520}$ inch, we get $\frac{0.11617}{12}$ feet for the excess of the chain's length above 100 feet; therefore $\frac{0.11617}{12} \times 365.9$ (chains) $= 3.542$ feet, is the correction for excess and wear; which add	+3.542
The sum of all the degrees shown by the thermometers, was 146051; wherefore $\overline{\frac{146051}{5} - 54° \times 365.9} \times \frac{0.0075}{12} = 5.232$ feet, is the correction for the mean heat in which the base was measured above 54°, the temperature to which the chains were reduced; and this add - - - -	+5.232
Hence these corrections, added to the apparent length, give - - - -	36598.835
Again, for the reduction to the temperature of 62°, *viz.* for 8° on the brass scale, we have $\frac{0.01237 \times 365.9 \times 80}{12} = 3.017$ feet; which subtract - -	−3.017
By the tables, the sum of the versed sines of the hypothenuses, or the corrections for reducing them to the plane of the horizon, is 20.916 feet; and this subtract - - -	−20.916
	36574.902

The sum of the corrections, for the reduction of the several horizontal lines from the height of the different hypothenuses above the centre of the earth, to the height of Beacon Hill above ditto, is 0.521 feet; this add - - - - + 0.501

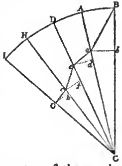
Therefore the apparent length of the base, as reduced to the level of Beacon Hill, is - - feet 36575.401

But it will be hereafter shown, that the height of Beacon Hill above the sea is 690 feet nearly, and that of King's Arbour 118, and of Hampton Poorhouse 86 feet; therefore the height of Beacon Hill above the mean point between King's Arbour and Hampton Poorhouse, is 588 feet, or 98 fathoms.

Now as the base thus reduced, may be supposed to have been measured 98 fathoms farther from the centre of the earth, than that on Hounslow Heath, it must be reduced to the same level. Therefore if we take 3481794 fathoms from the mean semi-diameter, and add 98 fathoms to it, we shall get the length by this proportion, *viz.* 3481892 : 3481794 :: 36575.4 : 36574.4, the length of the base nearly.

With respect to that step by which the base is reduced to the level of Beacon Hill, or the correction 0.501 foot is obtained, it will be proper to show on what principle it is founded.

In the adjoining figure, let B *a*, *a e*, *e c*, and *c* O be the several hypothenuses, or measured lines; then will the sum of the corrections for their reduction to the plane of the horizon, as given in the table, exhibit that of the differences between the horizontal lines, *b a*, *d e*, *f c*, *b* O, and their corresponding hypothenuses.



Again, with the radius C B, C being the centre of the earth,

describe the arc B I, or that subtended by the base, and through the terminations of the several hypothenuses, draw the lines C A, C D, C H, and C I; then will the lines B A, A D, D H and H I be those to which the horizontal ones *b a*, *d e*, *f c*, and *b* O are to be reduced, and which may therefore be done by the proportions of the lines, C *a*, C *e*, C *c*, and C O, to the constant radius C B. Upon this principle, the correction 0.501 foot has been obtained, and which is the sum of the differences between the lines *b a*, *d e*, *f c*, and *b* O, and their corresponding ones in the arc B I.

Height of Beacon Hill above the Southern Extremity of the Base.

	Feet.
109. The sum of the perpendiculars or elevations in the fourth column, is - -	218.6937
And of the depressions in the fifth column -	634.8222
Therefore the depressions exceed the elevations	416.1285
The difference of the sums in the seventh and eighth columns, - - - add	13.35
Hence the sum is the height of the beginning of the first chain above the end of the last, namely -	429.48
But the handle of the chain at Beacon Hill was 6.7 feet above the stone, and at the other end it was 1.3 feet; therefore their difference is 5.4 feet, which subtract	5.4
Hence the surface of the stone at Beacon Hill is higher than the surface of the stone at Old Sarum	424.08

110. When this situation was first examined, and selected for the measurement, it was imagined that one of the extremities of the base would be fixed on somewhere near the southmost clump of fir trees, not far from the Amesbury road, because from that spot Highclere can be seen. Those trees are near the 52d hypothenuse, and therefore about a mile from Beacon Hill; consequently, if

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that situation had been fixed on, the base would have been no more than six miles, and the correction for the reduction of the hypothenuses to the plane of the horizon only about 16 feet.

Now, although we think that the fixing on Beacon Hill as the northern extremity, is justified from the circumstance of a mile being added to the base, which is conceived to be more than a counterbalance for any errors which may arise from measuring down the side of a hill; there were other reasons which made it proper; a principal one is, that by selecting that spot, the base can be applied as a test to the triangles, without making the connection by means of several small ones; and another is, that if a place near the trees had been fixed on, a station must afterwards have been chosen on Beacon Hill, in order to have a view of Long Knoll, near Maiden Bradley, and Inkpin Beacon towards Hungerford.

We shall now close the account of the base by observing, that this measurement has been almost without an alternative, since Sedgemoor, the only spot west of Salisbury proper for an operation of this kind, is about to be inclosed. Therefore had we not adopted this expedient, the triangles which may hereafter be carried on to the remote parts of the West of England, would probably have depended on the Hounslow Heath base. But we are led to believe, that this base has been measured with nearly the same accuracy which would have attended the operation, had the ground been nearly level; since there is a certainty of the angles formed by the hypothenuses and the plane of the horizon, being determined within a minute of the truth. Now if an error of a minute in those inclinations, supposing them all to lie the same way, produce only that of three inches in the whole base, it may be concluded that 36574.4 is very nearly its true length.

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Calculation of the Sides of the great Triangles. Pl. XX.

111. *Of the Division of the Series into different Branches.*

In order to methodize the process of computation, it has been considered as proper to divide the series into different branches, as the triangles of which they are composed seem naturally to resolve themselves into distinct classes.

The first branch, is that which immediately connects the base of departure on Hounslow Heath, with that of verification on Salisbury Plain, and is bounded by the sides connecting the stations, Hanger Hill, St. Ann's Hill, Bagshot Heath, Highclere, Beacon Hill, and Four Mile-stone on the north, and on the south side by Four Mile-stone, Dean Hill, Butser Hill, Hind Head, Leith Hill, and Banstead.

The second branch, is that which proceeds from the side Hind Head and Leith Hill, to the coast of Sussex and the Isle of Wight, and principally affords the sides which will be hereafter used in finding the distance between Beachy Head and Dunnose. This branch also proceeds westward for the survey of the coast, and is bounded by the sides connecting the stations Leith Hill, Hind Head, Butser Hill, Dean Hill, and Wingreen on the north, and on the south by those connecting the stations Nine Barrow Down, Motteston Down, Dunnose, Rook's Hill, Chanctonbury Ring, and Ditchling Beacon.

The third branch, is that which proceeds from the side Hanger Hill and Banstead, to Botley Hill and Leith Hill, and from thence towards Beachy Head and Brightling, joining the series formerly projected at Botley Hill and Fairlight Down; the branch being bounded to the westward by the sides connecting the stations Hanger Hill, Banstead, Leith Hill, Ditchling Beacon, and Beachy Head.

The fourth branch, or remaining class of triangles, is that by which the distance between Beachy Head and Dunnose is obtained, and is formed by the sides connecting the stations Beachy Head, Ditchling Beacon, Chanctonbury Ring, Rook's Hill, and Dunnose.

Of the Selection of the Angles constituting the principal Triangles, and the Manner of reducing them for Computation.

112. The angles of the several triangles, constituting the general series, are, with a very few exceptions, those arising from using the means of the several observations given in the foregoing part of this work; for although the rejecting of such as might apparently suit the purpose, would give the sums of the three angles of many of the triangles, nearer to 180 degrees *plus* the computed excess; yet as all the observations have been made with equal care, and are for the most part to be considered as of equal accuracy, it has been thought proper to select those means, as being the fairest mode of proceeding.

If the observations had been made on a sphere of known magnitude, and the angles accurately taken, the most natural method of computing the sides of the triangles from the measured bases, would be by spherical trigonometry; but if the magnitude was such, that the length of a degree of a great circle was equal to a degree of the meridian in these latitudes nearly, in order to obtain the sides true to a foot from such computation, with any facility, a table of the logarithmic sines of small arcs computed to every $\frac{1}{100}$ of a second of a degree, would be necessary, because the length of a second of a degree on the meridian is about 100 feet. As the lengths of small arcs and their chords are nearly the same (the difference in these between Beachy Head and Dunnose being less than 4 feet) it is evident this business might be performed sufficiently near the truth

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in any extent of a series of triangles, by plane trigonometry, if the angles formed by the chords could be determined pretty exact. We have endeavoured to adopt this method in computing the sides of the principal triangles, in order to avoid an arbitrary correction of the observed angles, as well as that of reducing the whole extent of the triangles to a flat, which evidently would introduce erroneous results, and these in proportion as the series of triangles extended.

In the *Connoissance des Temps* for 1793, M. Delambre has given three tables, by which the angles of a spherical triangle may readily be reduced to those formed by the chords. But the Astronomer Royal has favoured us with the following investigation, which is extended so as to render the tables unnecessary for this purpose.

Demonstration of M. Delambre's Formula for reducing a Distance on the Sphere to any great Circle near it, or the contrary. By Nevil Maskelyne, D. D. F. R. S. and Astronomer Royal.

113. Put $\mathrm{A} =$ angle subtended by two terrestrial objects; $a =$ the same reduced to the horizon; H, b the two apparent altitudes: if either is a depression, it must be taken negative.

By spherics, $c, \mathrm{A} = c, a . c, \mathrm{H} . c, b + s, \mathrm{H} . s, b$.

Put $\mathrm{A} = a + da$, where da signifies $\mathrm{A} - a$, and not their differential.

By trigonometry, $c, \mathrm{A} = c, a . c, da - s, a . s, da = c, a \times \overline{1 - vs, da} - s, a . s, da = c, a - c, a \times 2s^2, \tfrac{1}{2} da - s, a . s, da$ (by theorem above) $= c, a . c, \mathrm{H} . c, b + s, \mathrm{H} . s, b \because s, da + 2s^2, \tfrac{1}{2} da . {}'t, a = {}'t, a - {}'t, a . c, \mathrm{H} . c, b - s, \mathrm{H} . s, b \times$ cosec. $a = t', a - {}'t, a \times \overline{\tfrac{1}{2} c, \overline{\mathrm{H} - b} + \tfrac{1}{2} c, \overline{\mathrm{H} + b}}$ — cosec. $a \times \overline{\tfrac{1}{2} c, \overline{\mathrm{H} - b} - \tfrac{1}{2} c, \overline{\mathrm{H} + b}}$ (because $t', a = \tfrac{1}{2}{}'t, \tfrac{1}{2} a - \tfrac{1}{2} t, \tfrac{1}{2} a$; and cosec. $a = \tfrac{1}{2}{}'t \tfrac{1}{2} a$

$+ \frac{1}{2} t, \frac{1}{2} a) = \overline{\frac{1}{2} t', \frac{1}{2} a - \frac{1}{2} t, \frac{1}{2} a} \times \overline{1 - \frac{1}{2} c, \overline{H - b} - \frac{1}{2} c, \overline{H + b}}$
$- \overline{\frac{1}{2} 't, \frac{1}{2} a + \frac{1}{2} t, \frac{1}{2} a} \times \overline{\frac{1}{2} c, \overline{H - b} - \frac{1}{2} c, \overline{H + b}} = \frac{1}{2} 't, \frac{1}{2} a$
$\times \overline{1 - c, \overline{H - b}} - \frac{1}{2} t, \frac{1}{2} a \times \overline{1 - c, \overline{H + b}} = \frac{1}{2} 't, \frac{1}{2} a \times vs, \overline{H - b}$
$- \frac{1}{2} t, \frac{1}{2} a \times vs, \overline{H + b} = 't, \frac{1}{2} a . s^2, \frac{1}{2} \overline{H - b} - t, \frac{1}{2} a . s^2, \frac{1}{2} \overline{H + b}.$
Put $n = 't, \frac{1}{2} a . s^2, \frac{1}{2} (H - b) - t, \frac{1}{2} a . s^2, \frac{1}{2} (H + b)$,

We shall have
$s, d a + 2 s^2, \frac{1}{2} d a . 't, a = n$;
and $s, d a = n - 2 s^2, \frac{1}{2} d a . t', a$.
But $s, d a = 2 s, \frac{1}{2} d a . c, \frac{1}{2} d a$
$\because s, \frac{1}{2} d a = \frac{s, d a}{2 c, \frac{1}{2} d a} = \frac{n - 2 s^2, \frac{1}{2} d a . 't, a}{2 c, \frac{1}{2} d a}$,
and $s, d a = n - 2 s^2, \frac{1}{2} d a . t', a = n - 2 t', a \left(\frac{n - 2 s^2, \frac{1}{2} d a . 't, a}{2 c, \frac{1}{2} d a}\right)^2$,
because $\overline{\frac{n - 2 s^2, \frac{1}{2} d a . t a}{2 c, \frac{1}{2} d a}}\Big|^2 = \frac{n - 4 n . s^2, \frac{1}{2} d a . t', a + 4 s^4, \frac{1}{2} d a . 't^2, a}{4 \times \overline{1 - s^2, \frac{1}{2} d a}}$
$= \frac{n^2}{4} + \frac{n^2 s^2, \frac{1}{2} d a .}{4} - (n . s^2, \frac{1}{2} d a . 't, a - n . s^4, \frac{1}{2} d a . 't, a$
$+ s^4, \frac{1}{2} d a . 't^2, a) = n - \frac{1}{2} n^3 . t', a - \frac{1}{2} n^3 . 't, a . s^2, \frac{1}{2} d a$
$+ 2 n . 't^2, a . s^2, \frac{1}{2} d a + 2 n 't^2, a . s^4, \frac{1}{2} d a - 2 't^2, a . s^4 + \frac{1}{2} d a$,
by substituting for $s, \frac{1}{2} d a$ its near value n,
$= n - \frac{1}{2} n^3 t', a - \frac{n^4 t', a}{8} + \frac{1}{2} n^5 t^2, a + \frac{1}{8} n^5 't^2, a - \frac{1}{8} n^6 't^3, a$,
where the last term but one containing the 5th power of n may be rejected, as it has been omitted by M. Delambre.

As $d a$ is always very small, the arc $d a$ in parts of the radius, unity, $= s, d a$ in parts of the same radius, therefore
$s, 1'' : 1'' :: s, d a$ (in parts of radius unity) : $\frac{1}{s, 1''} \times s, d a = d a$ in seconds,
$= \frac{1''}{s, 1''} \times \overline{n - 2 s^2, \frac{1}{2} d a . 't, a} = \frac{1''}{s, 1''} \times \overline{n - d a . s, \frac{1}{2} d a . 't, a} = \frac{1'' \times n}{s, 1''}$
$- \frac{1'' \times d a . s, \frac{1}{2} d a . 't, a}{s, 1''}$ $\because$ if we put $n = \frac{1''}{s, 1''} \times t', \frac{1}{2} a . s, \frac{1}{2} (H - b)$
$- t, \frac{1}{2} a . s^2, \frac{1}{2} (H + b)$, and $da = a$ number of seconds, we shall

have, $d\,a = n - d\,a\,.\,s,\,\frac{1}{2}\,d\,a\,.\,'t,\,a$; and, for the most part, without any sensible error, $d\,a = n - n\,.\,s,\,\frac{1}{2}\,n\,.\,'t,\,a$.

Table I. contains $\frac{1'' \times t,\,\frac{1}{2}a}{10000}$, and $\frac{1'' \times 't,\,\frac{1}{2}a}{10000}$; Table II. contains $10000 \times s^2,\,\frac{1}{2}\,(H \mp b)$. Table III. contains the term $-\,n\,.\,s,\,\frac{1}{2}\,n\,.\,'t,\,a$. The argument on the side is a, and that on the top is n or the result found by the help of the two first tables. If this correction should be considerable, with the value of da, found after this correction has been applied, enter Table III. again at the top, and with a on the side as before; the number now found subtracted from n will give the correct value of $d\,a$.

By the investigation,

$d\,a = \frac{1}{2}\,'t,\ \frac{1}{2}\,a\,.\,v\,s\,\overline{H \simeq b} - \frac{1}{2}\,t,\ \frac{1}{2}\,a\,.\,vs,\ \overline{H \pm b} - v\,s,\ d\,a\,.\,'t\,a,$

where the upper or lower signs are to be used, according as the objects are on the same, or on contrary sides of the great circle to which they are referred; the third term will be negative or positive, according as a is less or more than 90°.* If da should come out negative, A will be less than a, or a greater than A. In the case of reducing a spheric angle to the angle between the chords, the spheric angle will be represented by a, and the angle between the chords by $A = a + d\,a$; and $d\,a = \frac{1}{2}\,'t,\ \frac{1}{2}\,a\,.\,vs,$ $\overline{H \sim b} - \frac{1}{2}\,t,\,\frac{1}{2}\,a\,.\,v\,s,\,\overline{H + b} - v\,s,\,d\,a\,.\,'t,\,a$ (if D, d represent the arcs to the chords) $= \frac{1}{2}\,'t,\,\frac{1}{2}\,a.vs,\,\frac{1}{2}\,(D \sim d) - \frac{1}{2}\,t,\,\frac{1}{2}\,a\,.\,v\,s,\,\frac{1}{2}\,(D + d)$ $-\,vs,\,d\,a\,.\,'t,\,a$;

$A = a - (\frac{1}{2}t,\,\frac{1}{2}\,a\,.\,vs,\,\frac{1}{2}\,\overline{D + d} - \frac{1}{2}'t,\,\frac{1}{2}a\,.vs\,\frac{1}{2}\,D \sim d) - vs,\,da\,.'t,\,a;$

where the last term will change its sign to affirmative, if a is greater than 90°. If the answer is required in seconds, the correction must be multiplied by 206265, the number of seconds in

* Compute the two, which will give the approximate value of da, and make use of them in computing the third term; and join the three terms together according to their signs, which will give $d\,a$ still nearer; and, if this should prove considerable, compute the third term a second time with the new value of $d\,a$.

an arc = radius. The calculation will be easily made by logarithms.

Practical Rule.

The practical rule deduced from the above conclusions is the following, and given in the words of the Astronomer Royal.

"To the constant logarithm 5.0134 add $L.t, \frac{1}{2}a$ and $L.vs$ "$\overline{D+d}$; the sum diminished by 20 in the index is the logarithm "of the first part of the value of da in seconds, which is always "negative. To the constant logarithm 5.0134 add $L.t', \frac{1}{2}a$, and "$L.vs, \frac{1}{2}\overline{D \sim d}$, t e sum diminished by 20 in the index, is the "logarithm of the second part in seconds, which is always affir-"mative. These two joined together, according to their proper "signs, will give the approximate value of da. To its logarithmic "versed sine, add $L.t', a$ and constant logarithm 5.3144, the "sum, diminished by 20 in the index, will be the logarithm of "the third part in seconds, which will be negative or affirmative, "according as a is less or more than 90°. This applied according "to its sign, to the approximate value of da, will give the correct "value of da. If the third part comes out considerable, it should "be computed anew with the last value of da. The value of da, "finally corrected, applied to a, will give A, the angle between "the chords."

In the application of the above rule, to the computation of such corrections as may be applied to the angles of any triangle in this Survey, it is manifest that the last step may be entirely neglected on account of the smallness of the *approximate* value of da, whose versed sine is one of the arguments. Being, therefore, confined to the use of the two first steps, the operation is very short. An example is here given in the computation of the correction for reducing the angle at Chanctonbury Ring in the xxxixth triangle, to that formed by the chords.

EXAMPLE.

Constant logarithm - -	5.0134	- - - - -	5.0134
Log. tang. $\frac{1}{2}a = 78^\circ\ 56'$ -	10.7112	Log. co. tang. $\frac{1}{2}a$ - -	9.2887
Log. $vs.\ \frac{1}{2}.\overline{H+b} = 19'\ 53''.5$	5.2237	Log. $vs.\ \frac{1}{2}\overline{H-b} = 5'\ 53''.5$	4.1669
	$0.9483 + 8''.88$		$-\ 2.4690 + 0''.03$

1st correction $-\ 8.88$

2d correction $+\ 0.03$

$-\ 8.85$ the correction required.

114. When the three angles of any triangle appear to have been observed correctly, by their sum being equal to 180 degrees *plus* the computed excess, the corrections for the chord angles have been added to, or taken from them, as that correction has been negative or affirmative, and the triangle rendered fit for computation. Also, if in any triangle, where the sum has either fallen short of, or exceeded 180 degrees *plus* the computed excess, one or two of the observed angles have appeared to have been determined with sufficient accuracy, as shown by the agreement of the angles obtained upon different parts of the arch: the corrections for the chord angles have been added to, or taken from them, and the remaining angle or angles considered as erroneous. In the case of one angle being supposed right, and the other two wrong, the errors have been considered equal between the latter, unless the sum of the angles round the horizon at one of the stations, has indicated, that either the whole, or the greatest part of the excess or defect, was due to a particular angle. Likewise, when any triangle has been found in excess or defect, and all the angles have appeared to be determined with equal accuracy, the corrections for the reduction to the angles formed by the chords have been first applied, and then the errors considered equal.

What is called the spherical excess in the fifth column, is computed according to the rule, page 138. These excesses above 180° would, of course, be exactly the same as the respective sums of the

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differences between the spherical angles and those formed by the chords, in the fourth column, if both were not obtained from approximating rules.

It is almost unnecessary to remark, that no computations have been attempted with the chords of the sides of the lesser triangles in the principal series.

115. BRANCH 1. *Consisting of the Triangles which connect the Base of Departure on Hounslow Heath with that of Verification on Salisbury Plain.*

Distance from King's Arbour to Hampton Poorhouse, 27404 2 Feet.

No. of triangles.	Names of the stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
I.	St. Ann's Hill -	44 18 52 25				44 18 51.75	
	Hampt. Poorhouse	61 26 34 5				61 26 33.75	
	King's Arbour -	74 14 35.25				74 14 34.5	
		180 0 2		0.21	+1.79		
	St. Ann's Hill from { Hampton Poorhouse					— — —	37753.5
	King's Arbour -					— — —	34455.2
II.	Banstead -	25 15 42.25				25 15 41	
	King's Arbour	71 46 23 25				71 46 22	
	St. Ann's Hill	82 57 58 25				82 57 57	
		180 0 3.75		0.62	+3.13		
	Banstead { King's Arbour -					— — —	80131.6*
	St. Ann's Hill -					— — —	76687.7
III.	Hanger Hill -	24 39 16.5				24 39 16.5	
	Hampt. Poorhouse	130 3 3.25				130 3 3	
	St. Ann's Hill -	25 17 40.75				25 17 40.5	
		180 0 0.5		0.26	+0.24		
	Hanger Hill { Hampton Poorhouse					— — —	38670
	St. Ann's Hill -					— — —	69278.3*
IV.	Banstead -	53 22 39.75	−0.35			53 22 39.5	
	Hanger-hill -	62 40 34.75	−0.39			62 40 34.25	
	St. Ann's Hill -	63 56 46.75	−0.39			63 56 46.25	
		180 0 1.25		1.1	+0.15		
	Banstead { Hanger Hill -					— — —	77547.4*
	St. Ann's Hill -					— — —	76688.4

By these triangles, the distances from St. Ann's Hill to Banstead are 76687.7 feet, and 76688.4 feet; the mean of which is 76688 feet; and with this distance the sides marked with asterisks have been determined by working back.

Banstead from St. Ann's Hill, 76688 feet.

No. of triangles.	Names of the stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
V.	Leith Hill -	58 19 22.5	−0.35			58 19 22.25	
	Banstead -	77 37 35.5	−0.44			77 37 35	
	St. Ann's Hill -	44 3 3	−0.33			44 3 2.75	
		180 0 1		1.1	−0.1		
	Leith Hill { Banstead -					— — —	62655.2
	Leith Hill { St. Ann's Hill -					— — —	88019.8

Quadrilateral, formed by the Sides, St. Ann's Hill and Bagshot Heath, Bagshot Heath and Hind Head, Hind Head and Leith Hill, Leith Hill and St. Ann's Hill.

St. Ann's Hill from Leith Hill 88019.8 Feet.

No. of triangles.	Names of the stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
VI.	Hind Head -	51 10 39.75	−0.5			51 10 39.25	
	St. Ann's Hill -	46 40 30.5	−0.47			46 40 30.25	
	Leith Hill -	82 8 51	−0.7			82 8 50.5	
		180 0 1.25		1.7	−0.45		
	Hind Head { St. Ann's Hill -					— — —	111917.4*
	Hind Head { Leith Hill -					— — —	82187.8*
VII.	Bagshot Heath -	47 57 7	−0.53			47 57 6.5	
	Leith Hill -	56 37 29.5	−0.53			56 37 29	
	Hind Head -	75 25 25.25	−0.63			75 25 24.5	
		180 0 1.75		1.7	+0.05		
	Bagshot Heath { Leith Hill -					— — —	107115.9*
	Bagshot Heath { Hind Head -					— — —	92425.9*
VIII.	Bagshot Heath -	53 52 14.25	−0.16			53 52 14.25	
	Leith Hill -	25 31 21.5	−0.2			25 31 22	
	St. Ann's Hill -	100 36 23.5	−0.6			100 36 23.75	
		179 59 59.25		0.96	−1.71		
	Bagshot Heath from St. Ann's Hill -					— — —	46955.3*
IX.	Bagshot Heath -	101 49 22.25	−0.02			101 49 21.75	
	Hind Head -	24 14 45.5	−0.21			24 14 45.25	
	St. Ann's Hill -	53 55 53	−0.17			53 55 53	
		180 0 0.75		1.0	−0.25		
	Bagshot Heath from St. Ann's Hill -					— — —	46955.4*

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Bagshot Heath from Hind Head 92425.9 Feet.

No. of triangles.	Names of the stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
X.	Highelere -	34 56 15.75	—0.81			34 46 15	
	Bagshot Heath -	83 20 14 25	—1.36			83 20 14	
	Hind Head -	34 46 15 75	—0 88			61 53 31	
		180 0 1 75		3 09	—1 34		
	Highclere { Bagshot Heath -					— — —	142952.6*
	Highclere { Hind Head -					— — —	160972.2*
XI.	Butser Hill -	84 31 45.5	—1.2			84 31 44.5	
	Hind Head -	66 15 54.5	—0.83			65 15 54.25	
	Highclere -	29 12 22	—0 72			29 12 21.25	
		180 0 2		2.7	—0.7		
	Butser Hill { Hind Head - -					— — —	78905.7*
	Butser Hill { Highelere - -					— — —	148031 0*
XII.	Dean Hill -	62 22 48 75	—1.37			62 22 47	
	Butser Hill -	48 28 41.5	—1.23			48 28 40	
	Highclere -	69 8 35	—1.5			69 8 33	
		180 0 5.25		4 07	+1.18		
	Dean Hill { Butser Hill -					— — —	156122 1*
	Dean Hill { Highclere -					— — —	125084 9*
XIII.	Beacon Hill -	102 45 23.5	—0.9			102 45 22	
	Highclere -	26 55 51.5	—0.26			26 55 50.75	
	Dean Hill -	50 18 47.5	—0.15			50 18 47.25	
		180 0 2.5		1.3	+1.2		
	Beacon Hill { Highclere - -					— — —	98694.4
	Beacon Hill { Dean Hill - -					— — —	58086.3

Triangles which connect the Base of Verification with the Sides Beacon Hill and Highclere, and Beacon Hill and Dean Hill.

No. of triangles.	Names of the stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
XIV.	Thorney Down	53 22 30				53 22 31 25	
	Highclere -	12 59 10				12 59 10 75	
	Beacon Hill -	113 38 16.75				113 38 18	
		179 59 56 75		0.6	—3.85		
	Thorney Down { Highclere - -					— — —	112656
	Thorney Down { Beacon Hill - -					— — —	27634.4

No. of triangles.	Names of the stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
XV.	Old Sarum -	48 26 4.5				48 26 4.5	
	Thorney Down	98 0 31				98 0 30.75	
	Beacon Hill -	33 33 24.75				33 33 24.75	
		180 0 0.25		0.13	+0.12		
	Old Sarum from Thorney Down -					— — —	20416.1
XVI.	Four Mile-stone	72 4 48				72 4 47.5	
	Dean Hill -	39 29 3.25				39 29 3	
	Beacon Hill -	68 26 10				68 26 9.5	
		180 0 1.25		0.5	+0.75		
	Four Mile-stone { Dean Hill - -					— — —	56775
	Four Mile-stone { Beacon Hill -					— — —	38818.2
XVII.	Old Sarum -	85 58 22.5				85 58 21.75	
	Four Mile-stone	70 1 47.5				70 1 47	
	Beacon Hill -	23 59 51.75				23 59 51.25	
		180 0 1.75		0.14	+1.61		
	Old Sarum from Four Mile-stone -					— — —	15826.4

The Length of the Base of Verification deduced from that on Hounslow Heath, and the foregoing Triangles.

116. The base on Hounslow Heath is 27404.2 feet, which, with the four first triangles, give 76688 feet for the mean distance of St. Ann's Hill and Banstead.

That mean distance, with the V. VI. VII. X. XI. XII. XIII. XVI. XVII. triangles, will give 36574.7 feet for the base of *verification.*

If the computation be made with the VIII. and IX. triangles also, and the mean distance taken between Hind Head and Bagshot, the base will be 36574.3.

And those mean distances of St. Ann's Hill and Banstead, and Hind Head and Bagshot, with the XIV. and XV. triangles (excluding the XVI. and XVII.), will produce 36574.6 and 36574.9 respectively.

Lastly;—if the computations are carried directly from one base

to the other, independent of the mean distances and the xiv. and xv. triangles, the greatest and least results will be 36574.8, and 36573.8, the mean being 36574.3, feet, or about an inch short of the measurement.

Of the several ways by which the base of verification, or distance between Beacon Hill and Old Sarum is deduced, the first seems to have the preference, because the angles of the vi. and vii. triangles appear to have been observed very correctly. The results from the xiv. and xv. triangles cannot be considered as very conclusive, because the angle at Highclere is so acute that a trifling error in it will vary the distance from Beacon Hill to Thorney Down very considerably; and we had some reasons for being dissatisfied with this angle, and also that in the same triangle at Thorney Down, on account of the strain in the clamp. (Art. 101.)

Although the result of this comparison might afford some reason for supposing, that the sides of the triangles in this branch would be sufficiently near the truth, were all of them computed from the base on Hounslow Heath, yet, to approach more nearly to their correct distances, those which are marked with asterisks, have been computed with each base, and a mean of the results taken. The remaining sides have been determined by the bases in their vicinity.

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117. BRANCH II. *Consisting of the Triangles which proceed from Hind Head and Leith Hill to the Coast of Sussex, Isle of Wight, &c.*

Hind Head from Leith Hill 82187.8 Feet, mean Distance.

No. of triangles.	Names of the stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
XVIII.	Chanctonbury Ring	45 10 46.5	−0.44			45 10 46	
	Leith Hill -	72 56 50.25	−0.7			72 56 49.25	
	Hind Head -	61 52 25.5	−0.62			61 52 24.75	
		180 0 2.25		1.8	+0.45		
	Chanctonbury Ring { Leith Hill -					— — —	102185.7
	Chanctonbury Ring { Hind Head					— — —	110774.4
XIX.	Chanctonbury Ring	86 44 41	−0.62			86 44 39 75	
	Leith Hill -	32 43 57.5	−0.39			32 43 56.5	
	Ditchling Beacon	60 31 24.75	−0.38			60 31 23.75	
		180 0 3 25		1.5	+1.75		
	Chanctonbury Ring from Ditchling Beacon -					— — —	63469 1
XX.	Rook's Hill -	82 42 45.75	−0.7			82 42 45.25	
	Chanctonbury Ring	47 12 38	−0.45			47 12 38	
	Hind Head -	50 4 37	−0.46			50 4 36.75	
		180 0 0.75		1.6	−0.85		
	Rook's Hill from Chanctonbury Ring -					— — —	85645.4
	Butser Hill from Hind Head (Triang. XI) 78905.7 Feet.						
XXI.	Butser Hill -	70 25 13	−0 39			70 25 13	
	Hind Head -	44 28 6.25	−0.3			44 28 6.25	
	Rook's Hill -	65 6 40.75	−0.36			65 6 40.75	
		180 0 0		1.1	−1.1		
	Rook's Hill { Hind Head -					— — —	81954.4
	Rook's Hill { Butser Hill -					— — —	60933.8
XXII.	Dunnose -	24 44 15.5	−0.52			24 44 16	
	Butser Hill -	80 21 58	−0 81			80 21 58.5	
	Rook's Hill -	74 53 45	−0.65			74 53 45.5	
		179 59 58.5		1.96	−3.46		
	Dunnose from Rook's Hill -					— — —	143558.9
XXIII.	Dunnose -	55 43 7	−1.53			55 43 6 75	
	Butser Hill -	76 12 22	−1.99			76 12 21.5	
	Dean Hill -	48 4 32.25	−1.54			48 4 31.75	
		180 0 1.25		5.0	−3.75		
	Dunnose { Butser Hill -					— — —	140580.4
	Dunnose { Dean Hill -					— — —	183496.2

No. of triangles.	Names of the stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
XXIV.	Dunnose -	53 12 27.25	−2.03			53 12 25.5	
	Dean Hill -	64 50 19	−2.26			64 50 16.75	
	Nine Barrow Down	61 57 19.75	−2.22			61 57 17.75	
		180 0 6		6.5	−0.5		
	Dunnose from Nine Barrow Down -					— — — *	188181.8
	Distance from Beacon Hill to Dean Hill, as got by the Base on Salisbury Plain - - -					— — —	58086.3
XXV.	Wingreen -	30 13 23	−0.35			30 13 22.5	
	Beacon Hill -	66 49 52.25	−0.39			66 49 51.5	
	Dean Hill -	82 56 47	−0.68			82 56 46	
		183 0 2.25		1.43	+0.82		
	Wingreen { Beacon Hill -					— — —	114522.4
	Wingreen { Dean Hill -					— — —	106089
XXVI.	Nine Barrow Down	39 34 28.75	−0.82			39 34 28.25	
	Wingreen -	88 58 47.75	−1.59			88 58 46.75	
	Dean Hill -	51 26 45.5	−0.82			51 26 45	
		180 0 2		3.24	−1.24		
	Nine Barrow Down { Wingreen -					— — —	130224.5
	Nine Barrow Down { Dean Hill -					— — —	166497
XXVII	Motteston Down	— — —	−1.71			72 48 37.5	
	Nine Barrow Down	56 9 55.25	−1.43			56 9 53.75	
	Dean Hill -	51 1 30	−1.3			51 1 28.75	
				4.41			
	Motteston Down { Nine Barrow Down					— — —	135489.6
	Motteston Down { Dean Hill -					— — —	144766
XXVIII.	Motteston Down	— — —	−1.61			62 39 30.5	
	Dean Hill -	61 53 20.75	−1.64			61 53 19	
	Butser Hill -	55 27 12	−1.47			55 27 10.5	
				4.7			
	Motteston Down from Butser Hill -					— — —	155023.4
XXIX.	Motteston Down	64 41 2	−0.35			64 41 4	
	Butser Hill -	20 45 10	−0 43			20 45 9.5	
	Dunnose -	94 33 47.5	−1 0			94 33 46 5	
		179 59 59.5		1.8	−2.3		
	Motteston Down from Dunnose -					— — —	55104.3

* This distance is the mean, as derived from the Salisbury Base, and from the side Butser Hill and Dean Hill.

The four sides of the first branch, namely, Beacon Hill and Dean Hill, Dean Hill and Butser Hill, and Butser Hill and Hind Head, have been used in the computation of the sides of this branch, because they are supposed to be nearly true: had, however, these triangles been considered as independent of those in the first branch, and the side Hind Head and Leith Hill been used as derived from the base on Hounslow Heath, nearly the same conclusions would have taken place; for the distance between Beacon Hill and Old Sarum would in that case be 36574.2 feet, which is only two and an half inches less than the measured base. This may be considered as a proof, that the angles of the triangles forming this branch are sufficiently correct, since the series which joins the two bases by this route, is nearly an hundred and twenty miles in extent. Some little variation in that result might be produced by a different correction of the angles of the XXIV. triangle: but as the angle at Butser Hill must be very nearly true, the other angles cannot, on any reasonable supposition, be so corrected as to make the computed base differ from the measured one more than six inches.

118. BRANCH III. *Proceeding from the Side Hanger Hill and Banstead to Botley Hill and Leith Hill, and from thence to Brightling and Beachy Head, joining the Triangles with those of the late General Roy at Botley Hill and Fairlight Down.*

Hanger Hill from Banstead 77547.4 Feet.

No. of triangles.	Names of the stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
XXX.	Shooter's Hill -	54 43 49.75				54 43 49.25	
	Hanger Hill -	62 18 50				62 18 49.5	
	Banstead -	62 57 22				62 57 21.25	
		180 0 1.75		1.4	+0.35		
	Shooter's Hill { Hanger Hill -					— — —	84596.3
	Shooter's Hill { Banstead -					— — —	84107

No. of triangles.	Names of the stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
XXXI.	Botley Hill -	85 39 58.5				85 39 58.25	
	Shooter's Hill	37 8 25.75				37 8 25.75	
	Banstead -	57 11 36				57 11 36	
		180 0 0.25		0.9	−0.65		
	Botley Hill { Shooter's Hill					— — —	70894.9
	Botley Hill { Banstead -					— — —	50927
XXXII.	Leith Hill -	31 21 10	−0.08			31 21 9.75	
	Banstead -	108 50 48.25	−0.53			108 50 47.73	
	Botley Hill -	39 48 2.5	−0.06			39 48 2.5	
		180 0 0.75		0.7	+0.05		
	Leith Hill from Botley Hill -					— — —	92631.5

In this triangle, using the side from Leith Hill to Banstead as got by the first branch, we find the distance between Leith Hill and Botley Hill to be 92632.9 feet; hence the mean distance is 92632.2 feet.

XXXIII.	Crowboro' Beacon	46 12 11.75	−0.45			46 12 11.25	
	Botley Hill -	89 35 1	−0.98			89 35 0.25	
	Leith Hill -	44 12 49	−0.45			44 12 48.5	
		180 0 1.75		1.9	−0.15		
	Crowborough Beacon { Botley Hill -					— — —	89492.5
	Crowborough Beacon { Leith Hill -					— — —	128331.9
XXXIV.	Ditchling Beacon	78 18 27	−0.91			78 18 25.5	
	Crowboro' Beacon	63 24 37.25	−0.69			63 24 36.25	
	Leith Hill -	38 16 59 75	−0 62			38 16 58.25	
		180 0 4		2.2	+1.8		
	Ditchling Beacon { Leith Hill -					— — —	117190.4
	Ditchling Beacon { Crowborough Beacon					— — —	81192.2
XXXV.	Brightling -	43 29 1.5	−0.16			43 29 1	
	Crowboro' Beacon	105 2 44	−0.76			105 2 42	
	Ditchling Beacon	31 28 17.75	−0.22			31 28 17	
		180 0 3.25		1.14	+2.11		
	Brightling { Crowborough Beacon					— — —	61597.6
	Brightling { Ditchling Beacon -					— — —	113942.3
XXXVI.	Beachy Head -	73 58 26.5	−0.77			73 58 26.5	
	Ditchling Beacon	46 32 19	−0.56			46 32 19.5	
	Brightling -	59 29 14	−0.64			59 29 14	
		179 59 59.5		2.0	−2.5		
	Beachy Head { Ditchling -					— — —	102132.4
	Beachy Head { Brightling -					— — —	86048

No. of triangles.	Names of the stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
XXXVII.	Fairlight Down	59 33 1.75	−0.39			59 33 1.75	
	Brightling -	80 44 19.25	−0.51			80 44 19.25	
	Beachy Head -	39 42 39	−0.36			39 42 39	
		180 0 0		1.28	−1.28		
		Fairlight Down { Brightling -				— — —	63773.1
		Beachy Head -				— — —	98513.7

Comparison of the Distances from Botley Hill to St. Ann's Hill, and Fairlight Down, deduced from the recent Observations, and those made in 1787, 1788.

119. The stations on St. Ann's Hill, Botley Hill, and Fairlight Down, connect our triangles with those of General Roy; and therefore the two distances from the middle station, Botley Hill, which are common to both series of triangles, afford the readiest, and indeed almost the only means of comparing independent deductions from both operations; the triangle St. Ann's Hill, King's Arbour, Hampton Poorhouse, excepted.

The distances from the station at the Hundred Acres to St. Ann's Hill and Botley Hill, (see the IV. and IX. triangles in Art. 57.) are 79209.7 and 48725.8 feet; and from the IV. V. and IX. triangles it appears, that the included angle at that station is 169° 25′ 21″.25; these give 127421.3 feet for the distance of St. Ann's Hill from Botley Hill.

According to our observations, the distances of St. Ann's Hill and Botley Hill from Leith Hill are 88019.8 and 92632.2 feet respectively, and the included angle for computation at Leith Hill 89° 40′ 32″; hence, from the recent triangles, the distance of the stations will be 127420 feet; which is about $1\frac{1}{3}$ feet less than the result from General Roy's triangles.

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To compute the distance of Fairlight Down from Botley Hill by means of the triangles in Art. 57, we shall make use of the mean distance of Hollingborn Hill from Fairlight Down, as deduced from both bases. This distance, 141752 feet (p. 142), with the XIII. XII. and XI. triangles (p. 141), give 150790 feet, for the distance of Hollingborn Hill from Botley Hill, and 88° 27′ 0″$\frac{1}{4}$, the included angle at Hollingborn Hill between Botley Hill and Fairlight Down: hence the distance of the latter station from Botley Hill will be 204274 feet.

For determining this line from our triangles, we have 92632.2 and 117190.4 feet, the distances of Botley Hill and Ditchling Beacon from Leith Hill; also 102132.4 and 98513.7 feet, the distances of Ditchling Beacon and Fairlight Down from Beachy Head, respectively: these, with the included angles at Leith Hill and Beachy Head, give Ditchling Beacon from Botley Hill 139567.4, and from Fairlight Down, 167986.5 feet, and the included angle at Ditchling Beacon 82° 41′ 6″.8; hence the distance from Botley Hill to Fairlight Down will be 204276 feet nearly; or 2 feet greater than the deduction from the other triangles.

120. BRANCH IV. *Consisting of the nearest Triangles to the northward of Beachy Head and Dunnose, for finding the Distance between those Stations.*

No. of triangles.	Names of the stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.
		° ′ ″	″	″	″	° ′ ″
XXXVIII.	Dunnose - -	15 43 0	+0.55			15 43 0.5
	Rook's Hill - -	137 16 48.5	−3.88			137 16 44.5
	Chanctonbury Ring -	27 0 13	+1.37			27 0 15
		180 0 1.5		1.96	−0.46	

By this triangle, using the distance from Rook's Hill to Chanctonbury Ring as found by the first branch, we get the distance between Rook's Hill and Dunnose, 143559.3 feet; but by the same branch, 143558.9 feet was found to be the distance; and if the side Butser Hill and Dean Hill be made the base, we shall get, by the XXII. and XXIII. triangles, the distance from Rook's Hill to Dunnose 143557.1 feet: hence 143558.4, the mean of these three distances with the above triangle, give 214498.4 feet, for the distance between Dunnose and Chanctonbury Ring.

No. of triangles.	Names of the stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.
		° ′ ″	″	″	″	° ′ ″
XXXIX.	Beachy Head - -	7 42 37	+2.56			7 42 40
	Rook's Hill - -	14 17 33.25	+5.12			14 17 38
	Chanctonbury Ring -	157 59 50.75	−8.85			157 59 42
		180 0 1		1.19	−0.19	

By this triangle, with the side Chanctonbury Ring and Rook's Hill, as found by the second branch, we get the distance between Chanctonbury Ring and Beachy Head, 157592.5 feet; and by the following triangle,

XL.	Beachy Head - -	13 58 29.5	+0.48			13 58 28
	Ditchling Beacon -	143 9 31.5	−2.35			143 9 30
	Chanctonbury Ring -	22 52 3.25	+0.99			22 52 2
		180 0 4.25		0.9	+3.35	

using the side Chanctonbury Ring and Ditchling Beacon as got by the second branch, we get another distance between Beachy Head and Chanctonbury Ring, namely, 157590.8 feet; wherefore the mean distance is 157591.6; and this, with the XXXIX. triangle, give 239160.2 feet for the distance between Rook's Hill

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and Beachy Head: hence we have four principal distances, namely,

Dunnose from $\left\{\begin{array}{ll}\text{Rook's Hill} & 143558.4 \\ \text{Chanctonbury Ring} & 214498.4\end{array}\right\}$ feet.

Beachy Head from $\left\{\begin{array}{ll}\text{Rook's Hill} & 239160.2 \\ \text{Chanctonbury Ring} & 157591.6\end{array}\right\}$ feet.

And these sides used in the two following triangles,

No. of triangles.	Names of the stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.
		° ′ ″	″	″	″	° ′ ″
XLI.	Beachy Head - -	20 46 53	−0.2			20 46 52.75
	Rook's Hill - -	122 59 14.5	−7.7			122 59 8
	Dunnose - - -	36 13 58	+1.17			36 13 59.25
		180 0 55		6.77	−1.27	
XLII.	Dunnose - -	20 30 58	+0.86			20 30 58.75
	Chanctonbury Ring -	130 59 37.75	−8.77			130 59 29
	Beachy Head - -	28 29 30	+1.92			28 29 32.25
		180 0 5.75		6.01	−0.26	

give the four distances of Beachy Head from Dunnose, as beneath;

$$\left.\begin{array}{l}339394.6 \\ 339395.0 \\ 339399.2 \\ 339401.5\end{array}\right\}\text{feet.}$$

Hence 339397.6, the mean, may be considered as very nearly the true distance.

In the correction of the angles of the triangles which compose this branch, we have been a little more particular than with the others of the series, as it is of much consequence that the distance between Beachy Head and Dunnose should not be left doubtful.

In the XLII. triangle, it must be observed, that there is a defect of $\frac{1}{4}''$ nearly in the sum of the observed angles; in the XXXVIII. about $\frac{1}{2}$ a second; and in the XLI. a defect of about $1''\frac{1}{4}$: the sum in the XXXIX. is nearly right, but the angles of it are considered as

residuary, or remaining angles; the triangle being too oblique to be admitted as a principal one in the series, though numbered and inserted as such.

Now it is evident, that if all the angles of the four triangles contained in the quadrilateral formed by the stations on Dunnose, Rook's Hill, Chanctonbury Ring, and Beachy Head, were accurately corrected for computation, the distance from Beachy Head to Dunnose would be found the same from each triangle, by making use of the side Rook's Hill and Chanctonbury Ring (which is common to the two most oblique ones): therefore, having assumed that distance, we found by computation, that if each of the above errors is supposed to be in *one angle* only of the respective triangles, these angles must be the three observed ones, namely, 28° 29′ 30″; 27° 0′ 13″; and 122° 59′ 14″.5; these are augmented accordingly, before the angles are finally corrected for computation. The angles of the XXXIX. triangle, resulting from those of the other triangles, are

Chanctonbury Ring	-	157° 59′ 51″.25
Rook's Hill	- -	14 17 32.75
Beachy Head	- -	7 42 37.25

before they are reduced to the angles formed by the chords.

121. *Triangles for finding the Distance of Nettlebed from Shooter's Hill.*

Names of the stations.	Observed angles.	Spherical excess.	Angles corrected for calculation.	Distances.
	° ′ ″	″	° ′ ″	Feet.
Leith Hill -	23 20 51		23 20 51	
Botley Hill -	125 28 1		125 28 1.25	
Shooter's Hill -	31 11 7.5		31 11 7.75	
	179 59 59.5	1.23		
Leith Hill from Shooter's Hill -				145696.2
Shooter's Hill -	36 8 50.75		36 8 49.5	
St. Ann's Hill -	77 31 32.75		77 31 30.75	
Leith Hill -	66 19 41.5		66 19 39.75	
	180 0 5	2.77		
Shooter's Hill { St. Ann's Hill -				136665.5
Shooter's Hill { Leith Hill - -				145698.6

Hence the mean distance between Shooter's Hill and Leith Hill is 145697.4 feet.

Names of the stations.	Observed angles.	Spherical excess.	Angles corrected for calculation.	Distances.
Nettlebed -	- -		23 44 58.75	
Hind Head -	94 9 57.5		94 9 56.25	
Leith Hill - -	62 5 6		62 5 5	
		3.48		
Nettlebed { Hind Head - -				180325.4
Nettlebed { Leith Hill - -				203531.5

Then, by using the sides Shooter's Hill and Leith Hill, and Nettlebed and Leith Hill, in the following triangle,

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Names of the stations.	Observed angles.	Spherical excess.	Angles corrected for calculation.	Distances.
	° ′ ″	″	° ′ ″	Feet.
Shooter's Hill -	56 48 31		56 48 29	
Leith Hill -	86 23 25.75		86 23 23.25	
Nettlebed -	- -		36 48 7 75	
		6.97	- -	

we get 242730 and 242732 feet for the distance of Shooter's Hill from Nettlebed, the mean being 242731 feet.

Of the Directions of the Meridians at Dunnose and Beachy Head; and the Length of a Degree of a great Circle, perpendicular to the Meridian, in Latitude 50° 41′.

Of the Direction of the Meridian at Dunnose with respect to Brading Staff.

122. On April 28th in the afternoon, the angle between the pole star, when at its greatest apparent elongation from the meridian, and the staff, was observed - - - - -	° ′ ″ 24 4 23
And on April 29th in the morning -	18 24 0
Wherefore half their sum is the angle between the meridian and Brading Staff, namely -	21 14 11.5
On May 12th, in the afternoon, the angle between the star and staff was observed -	24 4 29.5
And on May 13th, in the morning -	18 23 53.25
Wherefore half their sum is the angle between the meridian and Brading Staff, namely -	21 14 11.4

Hence 21° 14′ 11″.5 may be taken for the angle between the

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meridian and Brading staff, as determined by the double azimuths.

The apparent polar distances of the star, on these days which do not refer to corresponding observations on the opposite side of the meridian, are as follow :

	° ′ ″		Azim. ° ′ ″
April 21st	1 47 57.2	which, with the lat. of Dunnose, *viz.* 50° 37′ 8″ nearly, give the azimuths for those days	2 50 11.2
April 22d	1 47 57.4		2 50 11.5
May 5th	1 48 0.7		2 50 16.8

	° ′ ″
And these subtracted from the observed angles (102.) give - - - -	21 14 10.05
	21 14 10.5
	21 14 10.45

The mean of which is 21° 14′ 10″.3 for the angle between the meridian and the staff, which is a little more than 1″ different from that obtained by the double azimuths; we shall, however, take 21° 14′ 11″.5 for the true angle.

Of the Direction of the Meridian at Beachy Head with respect to Jevington Staff.

	° ′ ″
123. On August 1st, in the morning, the angle between the pole star and the staff was observed	24 38 20.25
And at night - - - -	30 19 49.5
Therefore half their sum is the angle between the meridian and Jevington staff, namely -	27 29 5
On August 2d, at night, the angle between the star and staff was observed - -	30 19 50.25
And on August 3d, in the morning -	24 38 23.5
Therefore half their sum is the angle between the meridian and Jevington staff, namely -	27 29 7

Hence 27° 29′ 6″, the mean by the double azimuths, may be taken as the angle between the meridian and the staff.

The apparent polar distances of the star, on those days which do not refer to corresponding observations on the opposite side of the meridian, are as follow :

		° ′ ″		Azim. ° ′ ″
July	15th	1 48 4.6	which, with the latitude of Beachy Head, *viz.* 50° 44′ 25″ nearly, give the azimuths for those days -	2 50 49.4
	16th	1 48 4.4		2 50 49.1
	26th	1 48 2.9		2 50 46.7
	30th	1 48 2		2 50 45.3
Aug.	11th	1 47 59.3		2 50 41

	° ′ ″
And these applied to the observed angles give -	27 29 5.1
	27 29 8.4
	27 29 5.7
	27 29 5.2
	27 29 6.25

The mean of which is 27° 29′ 6″.1, for the angle between the meridian and Jevington staff, being the same as that obtained from a mean of the double azimuths.

Determination of the Length of a Degree of a great Circle, perpendicular to the Meridian, in Latitude 50° 41′.

124. In Pl. XIX. fig. 1. let D and B be Dunnose and Beachy Head, and P the pole, forming the spheroidical triangle DPB ; and let C and A be the staffs at Jevington and Brading Down, respectively.

	° ′ ″
Now the angle at Dunnose, between the meridian and the staff, or PDA, was found by the double azimuths to be - - - -	21 14 11.5
And the angle between the staff and the station on Beachy Head, or ADB - - -	60 42 41.5
Therefore their sum is the angle between the meridian and the station on Beachy Head, or PDB ; which is - - -	81 56 53

Again; at Beachy Head the angle between the meridian and the staff, or PBC, was found by the double azimuths to be - - -	° 27	′ 29	″ 6
And the angle between the staff and the station on Dunnose, or CBD - - -	69	26	52
Therefore their sum is the angle between the meridian and the station on Dunnose, namely -	96	55	58

Hence, in the spheroidical triangle DPB, we have the angles PDB and P BD gie.

Again, (Pl. XIX. fig. 2.) let PGM be the meridian of Greenwich; then if MB be the parallel to the perpendicular at G, Greenwich, we have (Art. 131.) MB = 58848 feet, and GM = 269328 feet; therefore, taking 60851* fathoms for the length of the degree on the meridian, as derived from the difference of latitude between Greenwich and Paris, applied to the measured arc, (supposing the lat. of Paris $48°\ 50'\ 14''$), we get GM = $44'\ 15''.26$; consequently the latitude of the point M, (that of Greenwich being $51°\ 28'\ 40''$), is $50°\ 44'\ 24''.74$; and the co-lat. PM = $39°\ 15'\ 35''.26$.

With respect to the value of the arc M B, for the present purpose, it is not of consequence on what hypothesis it be obtained; but if 61173 fathoms be assumed for the length of a degree of a great circle perpendicular to the meridian at M, then M B = $9'\ 37''.19$, and the latitude of B, or Beachy Head, will be found = $50°\ 44'\ 23''.71$.

* In the original account of the operation in 1787, 1788, the degree in lat. 50° 10′ is 60842 fath. whence this in 50° 41′ was inferred; and is about 2 fath. less than that in the table, p. 168, which was obtained from *data* somewhat different. But there still remains an uncertainty respecting the length of this meridional degree; for if the latitude of Paris observatory is 48° 50′ 15″, the result will be about 7 fath. greater: see Art. 67. These variations however, in the value of a degree, are too trifling to be of any consequence in deducing the latitudes of the stations, &c.

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Again, (fig. 3.) let W B be the arc of a great circle perpendicular to the meridian of Beachy Head at B, meeting that of Dunnose in W; and let D R be another arc of a great circle perpendicular to the meridian of Dunnose in D, meeting that of Beachy Head in R; then we shall have two small spheroidical triangles W B D and R D B, having in each two angles given, namely, W D B = 81° 56′ 53″, and W B D = 6° 55′ 58″ in the triangle W B D; and D B R = 83° 4′ 2″, with B D R = 8° 3′ 7″ in the triangle D B R; and these reduced to the angles formed by the chords, give the following triangles for computation, namely,

$$\text{In the triangle W B D}\begin{cases} \text{W B D} = 6^\circ\ 55'\ 57''.2 \\ \text{W D B} = 81\ 56\ 52.4 \\ \text{D W B} = 91\ 7\ 10.4 \end{cases}$$

$$\text{And in the triangle B D R}\begin{cases} \text{B D R} = 8\ \ 3\ \ 6 \\ \text{D B R} = 83\ \ 4\ \ 1 \\ \text{D R B} = 88\ \ 52\ \ 53 \end{cases}$$

In which it must be noted, that the reduced angles are given to the nearest $\frac{1}{4}''$.

Now the chord of the arc B D, or the distance between Beachy Head and Dunnose, is 339397.6 feet (120.) which used in the

$$\text{Triangle W B D gives}\begin{cases} \text{B W} = 336115.6 \text{ feet} \\ \text{D W} = 40973.4 \text{ feet} \end{cases} \text{ and the triangle B D R }\begin{cases} \text{D R} = 336980 \text{ feet.} \\ \text{B R} = 37547.1 \text{ feet.} \end{cases}$$

Again; let B L and D E be the parallels of latitude of Beachy Head and Dunnose, meeting the meridians in L and E: then, to find L W and E R we have two small triangles which may be considered as plane ones, namely, L B W and E D R, in which the angles at W and R are given, nearly.

Now the excess of the three angles above 180° in the triangle D B W, considered as a spherical one, is 3″ nearly; therefore the angle D W B will be 91° 7′ 12″ nearly; hence B W L = 88° 52′ 48″: consequently the angle B L W = 90° 33′ 36″, and L B W = 0° 33′ 36″. Therefore with the chord of the arc W B = 336115.6 feet, we get W L = 3285.2 feet, which added to W D, as found above,

gives 44258.6 feet, for the distance between the parallels of Beachy Head and Dunnose.

Again, in the triangle B D R, considered as a spherical one, the excess is about $3''\frac{1}{2}$; hence, from the two observed angles at D and B, namely, $8°\ 3'\ 7''$, and $83°\ 4'\ 2''$, we get the third angle $BRD = 88°\ 52'\ 54''.5$; and taking the triangle ERD as a plane one, the other angles will be $0°33'\ 32''.75$ (EDR), and $90°\ 33'\ 32''.75$ (DER); therefore, with the chord of the arc $DR = 336980$ feet, we get $RE = 3288.2$ feet, which taken from BR, as found above, leaves 44258.9 feet for the meridional arc, or the distance between the parallels of Beachy Head and Dunnose; which is nearly the same as before.

This method of determining the distance between the parallels is sufficiently correct; but the same conclusion may be deduced from a different principle, thus:

Let the difference of longitude, or the angle at P, be found, on any hypothesis of the earth's figure, and likewise the latitudes of Beachy Head and Dunnose; with these compute the latitudes of the points R and W; then it will be found that the arc RE is $\frac{5}{100}''$ greater than LW; and since $\frac{1}{100}$ of a second on the meridian is nearly a foot, RE is 5 feet more than LW; hence $\frac{47547.1 - 5 + 40973.4}{2}$ $= 44257.8$ feet is the distance between the parallels, which is very nearly the same as found by the other method.

It seems therefore, that whatever be the value of the arch between those parallels in parts of a degree, the distance between them is obtained sufficiently near the truth; therefore, taking 60851 fathoms for the length of a degree on the meridian, we get the arch subtended by $44258.7 \text{ feet} = 7'\ 16''.4$, which subtracted from the latitude of Beachy Head, namely, $50°\ 44'\ 23''.71$, leaves $50°\ 37'\ 7''.31$ for the latitude of Dunnose.

We have therefore, for finding the length of the degree of a

great circle perpendicular to the meridian at Beachy Head, or Dunnose, the latitudes of the two stations, and the angles which those stations make with each other and the pole.

125. Since the sum of horizontal angles P D B + P B D (Pl. XIX. fig. 1.) is nearly the same as the sum which would be found on a sphere (62.), we shall find the angles for spherical computation as follows:

The co-latitudes of D and B, or the arches D P and B P, are $39° 22' 52''.69$, and $39° 15' 36''.29$, therefore half their sum is $39° 19' 14''.49$, and half their difference $3' 38''.2$.

Half the sum of the angles P D B and P B D is $89° 26' 25''.5$; therefore, (p. 157) as *tang*. $39° 19' 14''.49$: *tang*. $3' 38''.2$: : *tang*. $89° 26' 25''.5$: *tang*. $7° 31' 57''.71$, or half the difference of the angles: hence the angles for computation are $81° 54' 27''.79$, and $96° 58' 23''.21$, which, with the co-latitudes of D and B, give the difference of longitude between Beachy Head and Dunnose, or the angle D P B = $1° 26' 47''.93$.

We have now two right angled triangles (fig. 3.), which may be considered spherical, namely, PBW, and PDR, in which the angle at the pole P is given, and likewise the sides PB and PD; therefore, using these *data*, we find the arc B W = $54' 56''.21$, and the arc D R = $55' 4''.74$.

The chords of the two perpendicular arcs are about $3\frac{1}{2}$ feet less than the arcs themselves; therefore B W = 336119.1 feet, and D R = 336983.5 feet; and by proportioning these arcs to their respective values in fathoms, we get the length of the degree of the great circle perpendicular to the meridian in the middle point between W and B = 61182.8 fathoms, and in the middle point between R and D = 61181.8 fathoms. Therefore 61182.3 fathoms is the length of a degree of the great circle perpendicular to the meridian, in latitude $50° 41'$, which is nearly that of the middle point between Beachy Head and Dunnose.

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If the horizontal angles, or the directions of the meridians, have been obtained correctly, the difference of longitude between Beachy Head and Dunnose, as thus found, must be very nearly true; since the difference between the sums of the angles which would be observed on a spheroid and those on a sphere, having the latitudes and the difference of longitude the same on both figures as those places, is so small as scarcely to be computed: and it is easy to perceive, that the distance between the parallels is obtained sufficiently correct, since an error of 15 or 20 feet in that meridional arc, will vary the length of the degree of the great circle but a very small quantity.

126. It may possibly be imagined, that because the vertical planes at Dunnose and Beachy Head do not coincide, but intersect each other in the right line joining these stations, neither of the two included arcs is the proper distance between them, and that the nearest distance on the surface must fall between these arcs; but it is easy to show, that in the present case, the difference must be almost insensible.

In Pl. XIX. fig. 4, let B be Beachy Head, and E B P its meridian, and N and M, the points where the verticals from Beachy Head and Dunnose respectively meet the axis P P.

Now it is known, that if the planes of two circles cut each other, the angle of inclination is that formed by their diameters drawn through the middle of the chord, which is the line of intersection. Therefore, if we draw B M, and also conceive D to be Dunnose, and E P its meridian, and join D N; it is evident, that either of the angles N B M, N D M will be the inclination of the planes very nearly, because of the short distance between the stations, and their small difference in latitude. In the ellipsoid we have adopted, the distance M N is about 62 fathoms, and hence the angle N B M, or N D M, will be found between 2 and 3″. The value of the arc between the stations is about 55′ 30″, and its length 339401 feet;

hence the versed sine of half the arc will be 685 feet nearly; now, suppose the versed sines to form an angle of 3″, the greatest distance of the vertical planes on the earth's surface between the stations, will be but about $\frac{1}{10}$ of an inch.

It may also be remarked, that the inclination here determined, is the angle in which the vertical plane at one station cuts the vertical at the other; and therefore no sensible variation can arise in the horizontal angles, on account of the different heights of the stations.

127. If the figure of the earth be that of an ellipsoid, (fig. 5.) then B R, which is perpendicular to the surface at the point B, is the radius of curvature of the great circle, perpendicular to the meridian at that point; therefore the length of a degree of longitude is obtained by the proportion of the radius to the cosine of the latitude. Thus at Beachy Head, where the length of the degree of a great circle is 61183 fathoms nearly, we have this proportion; *rad.* : *cosine* 50° 44′ 24″ : : 61183 : 38718 fathoms, for the length of the degree of longitude. And at Dunnose, as *rad.* : *cosine* 50° 37′ 7″ : : 61182 : 38818 fathoms for the length of the degree of longitude, being about 100 different from the former. But nearly the same conclusions may be otherwise deduced; for the chords of the parallels may be found from the small triangles BWL and DER, (fig. 3.) and these, when augmented by the differences between them and the arcs, give the length of the degree of longitude at Beachy Head 38719 fathoms, and Dunnose 38819 fathoms.

128. *Problem.* Having the meridional degree, and also the degree perpendicular to the meridian, in a given latitude; to find the earth's axes, supposing it an ellipsoid.

Suppose (Pl. XIX. fig. 5.) APAP to be the elliptical meridian passing through the point B whose latitude is given; CA, CP the

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equatorial, and polar semi-axes. Let B F be the ordinate to the point B, and draw B R perpendicular to the curve at B, which will be the radius of curvature of the perpendicular degree at that point; also draw B D parallel to A C. Put c, and t, for the *cosine*, and *tangent* of the given latitude; p, and m, for the lengths of the perpendicular and meridional degrees, respectively; and $d = 57°.29$ &c. the degrees in the circular arc which is equal to the radius.

Then, from the properties of the ellipse, we get FC, or BD $= \frac{CA^2}{\sqrt{CA^2 + t^2 CP^2}}$; BR $= \frac{CA^2}{c\sqrt{CA^2 + t^2 CP^2}} = d\,p$, the radius of curvature of the perpendicular degree; and $\frac{CA^2 . CP^2}{c\sqrt{CA^2 + t^2 CP^2}|^3} = d\,m$ the radius of curvature of the meridional degree: but the two latter expressions are as 1 to $\frac{CP^2}{c^2 CA^2 + c^2 t^2 CP^2}$; therefore $1 : \frac{CP^2}{c^2 CA^2 + c^2 t^2 CP^2}$ $: : p : m$; hence, (putting $\frac{1}{t^2+1}$ for c^2, and $r = p - m$), we get $CP^2 :$ $CA^2 : : m : p + r\,t^2$, or $CP : CA : : 1 : \sqrt{\frac{p + r\,t^2}{m}}$, the ratio of the axes. Let $\sqrt{\frac{p + r\,t^2}{m}} = a$; then $CA^2 = a^2\,CP^2$ which substituted for CA^2, and we have $\frac{a^2 CP}{c\sqrt{a^2 + t^2}} = d\,p$, whence $CP = \frac{d\,p\,c}{a^2}\sqrt{a^2 + t^2}$; and consequently $CA = \frac{d\,p\,c}{a}\sqrt{a^2 + t^2}$.

Corol. 1. If l = the length of a *degree* of *longitude* at the point B, then BD will be its radius of curvature; therefore, *rad.* $: c : :$ BR $:$ BD $: : p : l$, hence $p = \frac{l}{c}$, which substituted in the above expressions, we get $\sqrt{\frac{l + c\,r\,t^2}{c\,m}} = a$; and $CP = \frac{d\,l}{a^2}\sqrt{a^2 + t^2}$; and CA $= \frac{d\,l}{a}\sqrt{a^2 + t^2}$, the semidiameters in this case.

Corol. 2. Because $\frac{CA^2}{c\sqrt{CA^2 + t^2 CP^2}} = BR = d\,p$; if b and T represent the *cosine* and *tangent* of some other latitude, and P the *perpendicular degree* in that latitude; then $\frac{CA^2}{b\sqrt{CA^2 + T^2 CP^2}} = d\,P$ the

radius of curvature of P. Hence $\frac{CA^2}{Pb\sqrt{CA^2 + T^2CP^2}} = d$: and the former equation gives $\frac{CA^2}{pc\sqrt{CA^2 + t^2CP^2}} = d$; these being equated, we get $P^2b^2 . \overline{CA^2 + T^2CP^2} = p^2c^2 . \overline{CA^2 + t^2CP^2}$. Let s, and S, be the *sines* to the *cosines* c, and b; and put $\frac{s^2}{c^2}$, and $\frac{S^2}{b^2}$ for t^2 and T^2; and we shall have CA : CP : : $\sqrt{p^2s^2 \sim P^2S^2} : \sqrt{P^2b^2 \sim p^2c^2}$, for the ratio of the axes; which being expounded by 1 : n, we have $CA^2 = n^2CP^2$, this substituted for CA^2 in the equation $\frac{CA^2}{pc\sqrt{CA^2 + t^2CP^2}} = d$, gives $CP = \frac{dpc}{n^2}\sqrt{n^2 + t^2}$; whence $CA = \frac{dpc}{n}\sqrt{n^2 + t^2}$. But the same values for the semi-axes will be obtained by substituting in the other equation.

Hence, if l and L be the *degrees* of *longitude* in the given latitudes, we have $p = \frac{l}{c}$, and $P = \frac{L}{b}$, which substituted for p, and P, and we shall get the expressions for the semi-axes in that case.

129. *Table, containing a Comparison between the Degrees upon the Meridian, which have been measured in different Latitudes, with those computed on three Ellipsoids.*

Deg. on meridian in lat. 50° 41′ -				1st. Ellipsoid. 60851 fath.		2d. Ellipsoid. 60870		3d. Ellipsoid. 60851	
Deg. perp. to meridian - -				61182		61182		61191	
	Lat. °	′	Measured Fath.	Computed.	Diff.	Computed.	Diff.	Computed.	Diff.
Bouguer, &c. - -	0	0	60482	60122	−360	60183	−299	60103	−379
Mason and Dixon -	39	12	60628	60607	− 21	60640	+ 12	60600	− 28
Boscovich, &c. -	43	0	60725	60687	− 38	60716	− 9	60683	− 42
Cassini - -	45	0	60778	60730	− 48	60756	− 22	60727	− 51
Leisganig - -	48	43	60839	60806	− 33	60831	− 8	60808	− 31
Between Greenwich and Paris	50	41	60851	60851	0	60870	+ 19	60851	0
Maupertuis, &c. -	66	20	61194	61148	− 46	61150	− 44	61156	− 38

The contents of the above table are computed from the *data* expressed in the different columns at top. In the third column,

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60851 fathoms is nearly the length of the degree upon the meridian, as derived by the application of the measured arc between Greenwich and Paris to the difference of latitude. (124.) The fifth, contains the degrees on an ellipsoid, computed from a different length of a degree upon the meridian in lat. 50° 41′, in order to show how far the varying the length of that degree, will affect the comparison between the measured and computed degrees on the first ellipsoid: and those in the seventh are determined by using 60851 fathoms for the degree upon the meridian, and 61191 fathoms for that of the great circle perpendicular to it; which last degree is obtained by taking the angle at Dunnose, equal to 81° 56′ 53″.5, instead of 81° 56′ 53″.

Now this comparison between the measured and computed degrees, seems to prove that the earth is not an ellipsoid, since the differences are, excepting two instances, constantly *minus;* this, however, presupposes that the degree of the great circle perpendicular to the meridian in lat. 50° 41′, as we have found it, and likewise the degree upon the meridian arising from the measured arc between Greenwich and Paris, and their difference in latitude, are nearly right. Also, were it of Mr. Bouguer's figure, the degree of a great circle in lat. 50° 41′ would be 61266 fathoms, which is 84 fathoms greater than we have derived it; we may therefore safely infer, that his hypothesis is more ingenious than true; since it cannot be supposed that the degree, resulting from these observations, is 84 fathoms in defect; but whether the earth be a figure formed by the revolution of a meridian round its axis, upon which the length of the degrees increase according to any law, or one whose meridians are formed by the combination of many different curves, it appears to be certain, that we may consider 61182 fathoms as nearly the length of the perpendicular degree, in latitude 50° 41′, by which we are enabled to settle the longitudes of those places whose situations have been determined in this operation.

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The length of the degree in latitude 50° 41′, obtained from the directions of the meridians at Botley Hill and Goudhurst, is 61248 fathoms nearly, which is 66 fathoms different from this result: but this is not to be considered as extraordinary, since the distance between those places is not more than 23 miles, and the direction very oblique to the meridian. The stations chosen for this purpose should be nearly east and west; because if both places were on the same parallel of latitude, the horizontal angles would give the difference of longitude, without adverting to the principle of the sums of the angles on a sphere and a spheroid being nearly equal, when the places on each have corresponding latitudes, and the same difference of longitude.

Was a degree of a great circle perpendicular to the meridian measured in some place remote from the latitude of 50° 41′, the diameters of the earth, supposing it an ellipsoid, might be determined from the perpendicular degrees only; (*Corol.* 2. Art. 128.) It is therefore, much to be wished, that such measurements were made in the northern part of Russia, and in the south of France, where the methods we have taken to measure this degree would also be applicable.

Having given the length of a degree of what may be considered a great circle upon the earth's surface, as deduced from the observations which have been made at Beachy Head and Dunnose, and likewise drawn such conclusions as appear to arise from it; we have to add, that as the preserving of the points marking these stations has been considered of great consequence, his Grace the Duke of Richmond ordered an iron gun to be inserted in the ground at each of those places, which was done in the autumn of 1794. By these points being rendered permanent, the truth of this part of the operation can be examined, by re-observing the directions of the meridians; and that this may be done with the least trouble, we have preserved the points, where the staffs were erected on

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Brading Down and the hill above Jevington, by inserting large stones in the ground, having a small hole in each of them, for the purpose of denoting the exact points over which the centres of the staffs were placed; therefore the angles which we have given, as being the directions of the meridians with respect to those points, can be examined without the trouble of firing lights at Beachy Head and Dunnose. There is, however, another method of determining whether 61182 fathoms be nearly the length of a degree of a great circle perpendicular to the meridian; this may be done by observing the directions of the meridians at Shooter's Hill and Nettlebed, whose distance is already determined, being 242731 feet nearly. The points marking these stations are not likely to be soon removed, and can be found without difficulty.

Of the Distances of the Stations from the Meridians of Greenwich, Beachy Head, and Dunnose; and also from the Perpendiculars to those Meridians.

130. In operations of this kind, the usual method of obtaining the distances of the stations from a first meridian, and from a perpendicular to that meridian, is by drawing parallels to those lines through the several stations, and then proceeding in a manner similar to that of working a traverse, after the bearings of the stations, with respect to these parallels, have been deduced from the angles of the triangles. This mode of computation might be considered as accurate, if the surface of the earth to the whole extent of the triangles was reduced to a flat: and it will not produce very erroneous results, if the series of triangles are in a north and south, or an east and west direction nearly, provided they are on, or near the meridian, or its perpendicular; but if the triangles are considerably extended, and in all directions, the bearings of the same stations (if they may be so termed) must evidently differ, and that

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sometimes considerably, when obtained from different triangles. To avoid, in a great measure, the errors which might affect the conclusions derived from the present triangles, if all those distances were determined from the meridian of Greenwich only, we have considered the meridians of Beachy Head and Dunnose as first meridians also, and, with two or three exceptions, calculated the distance of each station from its nearest meridian. Bagshot Heath, Leith Hill, Ditchling Beacon, and Beachy Head, with those to the eastward, are from the meridian of Greenwich and its perpendicular; Chanctonbury Ring from the meridian of Beachy Head; and the others to the westward, from that of Dunnose.

The advantages in this mode of proceeding are very obvious; for if the directions of meridians are taken at about 80 miles distance from each other, near the southern coast, the operation may be extended to the Land's End with sufficient accuracy, without making astronomical observations for determining any intermediate latitude, as a new point of departure.

In deducing the bearings of the several stations from the meridians and their perpendiculars, we have taken the observed angles, instead of those formed by the chords, which were used in computing the sides of the principal triangles; because the latter angles at each station may be considered as constituting the vertex of a pyramid, and consequently their sum is less than 360°; but the operation of determining the distances from the meridians, and their perpendiculars from those reduced, or pyramidical angles and the chords or sides of the triangles, independent of other *data*, would be very tedious. Great accuracy however, in these cases seems not absolutely necessary; because, if the latitudes and longitudes obtained from those distances can be depended upon to $\frac{1}{4}$ of a second (the latitude of Greenwich, from which the other latitudes are derived, being supposed exact), the conclusions will certainly be considered as sufficiently near the truth: 25 feet answers to about $\frac{1}{4}$ of a

second on the meridian; and it is not difficult to show, that no uncertainty of more than about 10 feet has been introduced, even in the longest distances, in consequence of using the observed angles.

As Botley Hill is nearly south of the Observatory at Greenwich, and it may be supposed, that the distance of it from the meridian, as well as perpendicular, must be nearly true, as given in p. 153, it has not been considered as expedient to make this part of the operation entirely independent of General Roy's, by selecting Greenwich for a station, and observing the direction of the meridian at that place with respect to Banstead, or Shooter's Hill.

In order, therefore, to obtain the necessary *data*, when the instrument was at Botley Hill, the angle between Banstead and the station on Wrotham Hill was observed, and found to be $152° 57' 4''$ (102.); from which subtracting $79° 16' 29''$ ($6° 50' 58'' + 72° 25' 31''$, or the bearing of Frant from Wrotham Hill, p. 153, added to the angle at Wrotham in the XI. triangle, p. 141) the angle which Wrotham Hill makes with the parallel to the meridian of Greenwich, we get $73° 40' 35''$ for the inclination of Banstead to that parallel; this, with 50927 feet, the distance of Banstead from Botley Hill, give 48874, and 14314 feet; therefore $48874 - 172 = 48702$ feet, is the distance of Banstead from the meridian of Greenwich; and $72881 - 14314 = 58567$ feet, the distance from the perpendicular.

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131. *Table containing the Bearings of the Stations from the Parallels to the different Meridians; and likewise their Distances from those Meridians and their Perpendiculars.*

Names of the stations.		Bearings.				Distance from the Meridian.	Distance from the Perpendicular.
		°	′	″		Feet.	Feet.
	Meridian of Greenwich.						
	Botley Hill - -	—			—	172	72881
Botley Hill -	Shooter's Hill -	11	59	23	NE	14899	3533
	Banstead - -	73	40	35	NW	48702	58567
	Leith Hill - -	66	31	22	SW	84792	109784
	Crowborough Beacon	23	3	39	SE	35227	155222
Hanger Hill -	Hampton Poorhouse	24	11	47	SW	83084	18540
Banstead - -	Hanger Hill -	13	49	33	NW	67234	16733
	King's Arbour -	41	56	31	NW	102261	1036
	St. Ann's Hill -	67	12	13	NW	119400	28854
Crowborough Beacon	Ditchling Beacon -	47	19	22	SW	24468	210257
Leith Hill - -		30	58	49	SE		
Crowborough Beacon	Brightling -	57	43	12	SE	87304	188119
Brightling - -	Fairlight Down -	61	25	47	SE	143312	218618
Ditchling Beacon -	Beachy Head -	54	39	48	SE	58848	269328
St. Ann's Hill - -	Bagshot Heath -	77	27	16	SW	165234	39055
	Merid. of Beachy Head.						
Beachy Head -	Chanctonbury Ring -	68	26	28	NW	146567	57908
	Meridian of Dunnose.						
Dunnose - -	Rook's Hill - -	45	42	55	NE	102770	100236
	Butser Hill - -	20	58	39	NE	50328	131263
	Dean Hill - -	34	44	27	NW	104568	150786
	Motteston Down -	73	35	8	NW	52858	15572
	Nine Barrow Down	87	56	55	NW	188061	6736
Butser Hill -	Highclere -	34	20	17	NW	33174	253495
Dean Hill -		34	48	11	NE		
Dean Hill -	Beacon Hill - -	15	30	36	NW	120101	206757
	Four Mile-stone -	54	59	39	NW	151073	183355
Beacon Hill -	Thorney Down -	4	57	42	SE	117871	179212
	Old Sarum - -	28	55	42	SW	137793	174746
Dean Hill - -	Wingreen -	81	32	37	SW	209505	135184
Nine Barrow Down		9	28	43	NW		
Rook's Hill -	- Hind Head - -	5	43	21	NE	112942	181782

132. *Latitudes and Longitudes of the Stations referred to the Meridian of Greenwich.*

Names of the stations.	Latitude.	Longitude. In degrees.	Longitude. In time.
	° ′ ″	° ′ ″	m. s.
Shooter's Hill - -	51 28 5.1	0 3 54.5 E	0 15.6
Crowborough Beacon -	51 3 9.4	0 9 9.5 E	0 36.6
Brightling - -	50 57 43.3	0 22 39.3 E	1 30.6
Fairlight Down - -	50 52 38.8	0 37 7.4 E	2 28.5
Beachy Head - -	50 44 23.7	0 15 11.9 E	1 0.7
Ditchling Beacon -	50 54 7	0 6 20.5 W	0 25.3
Leith Hill - - -	51 10 35.7	0 22 6.3 W	1 28.4
Banstead - -	51 19 2	0 12 44.1 W	0 50.9
Hanger Hill - -	51 31 23.7	0 17 39.6 W	1 10.6
Hampton Poorhouse -	51 25 35.2	0 21 46.6 W	1 27.1
King's Arbour - -	51 28 47.1	0 26 50 W	1 47.3
St. Ann's Hill - -	51 23 51.4	0 31 16.6 W	2 5.1
Bagshot Heath - -	51 22 7.1	0 43 15.4 W	2 53

133. *Latitude and Longitude of Chanctonbury Ring.*

Lat. of Chanctonbury Ring -	50° 53′ 48″.5		
Long. of Beachy Head, east of Greenwich - -	0 15 11.9		
Long. of Chanctonbury Ring, west of Beachy Head -	0 37 58.8		
Long. of Chanctonbury Ring, west of Greenwich -	0 22 46.9	— in time	1m. 31s.1

134. *Latitude and Longitude of Dunnose.*

Latitude of Beachy Head -	50 44 23.7
Difference of latitude between Beachy H. and Dunn. (124).	0 7 16.4
	50 37 7.3 lat. of Dunnose.

	° ′ ″	
The difference of long. between Beachy Head and Dunnose (125.) - -	1 26 47.9 W	
And the long. of Beachy Head, east of Greenwich -	0 15 11.9 E	
		m. s.
Therefore the long. of Dunnose, west of Greenwich, is	1 11 36 and in time	4 46.4

135. *Latitudes and Longitudes of the Stations referred to the Meridian of Dunnose.*

Names of the stations.	Latitude.	Longitude. from Dunnose.		Longitude. West of Greenwich. In degrees.	In time.
	° ′ ″	° ′ ″		° ′ ″	m. s.
Rook's Hill -	50 53 32.5	0 26 37.7	E	0 44 58.3	2 59.9
Hind Head -	51 6 56.1	0 28 53	E	0 42 43	2 50.9
Butser Hill -	50 58 40.8	0 13 3.8	E	0 58 32.2	3 54.1
Motteston Down	50 39 40	0 13 37.8	W	1 25 13.8	5 40.9
Highclere -	51 18 46.2	0 8 40.4	W	1 20 16.4	5 21.1
Dean Hill -	51 1 50.9	0 27 10.5	W	1 38 46.5	6 35.1
Beacon Hill -	51 11 4.4	0 31 18.9	W	1 42 54.9	6 51.7
Four Mile-stone	51 7 8.5	0 39 20.2	W	1 50 56.2	7 23.8
Thorney Down	51 6 30.2	0 30 40.8	W	1 42 16.8	6 49.1
Old Sarum -	51 5 44.7	0 35 51.5	W	1 47 27.5	7 9.9
Nine B. Down	50 38 3.5	0 48 27.8	W	2 0 3.8	8 0.3
Wingreen -	50 59 7.6	0 54 22.9	W	2 5 58.9	8 23.9

136. The longitudes and latitudes of the stations have been computed spherically, in which we have taken the degrees upon the meridian, and of the great circle perpendicular to it, from the following table.

	Degrees on the merid. Fath.	Degrees on the perp. Fath.		Fathoms.
Lat. 50° 41′	60851	61182	Semi-transverse of this ellipsoid -	3491420
Lat. 51 5	60859	61185		
Lat. 51 28 40	60868	61188	Semi-conjugate -	3468007

Ratio of the axes 1 : 1.006751, or nearly as 231 to $233\frac{1}{10}$.

This ellipsoid is determined from the length of the degree obtained from the directions of the meridians at Beachy Head and Dunnose, and that upon the meridian in lat 50° 41′, as resulting from the application of the measured arc between Greenwich and Paris, to their difference in latitude. It is not, however, to be understood, that by using it, we consider the earth to be this ellipsoid: we have adopted the hypothesis, because it is obvious some small increase northward must be made to the degree upon the meridian in 50° 41′, in order to approximate to a correct scale for the computation of the latitudes. But it is evident, that any of the received hypotheses (supposing the length of the degree upon the meridian in 50° 41′ to be 60851 fathoms nearly) would give the degrees sufficiently correct, since the principal stations, together with most of the objects fixed in this operation, are included between the parallels of 50° 37′ and 51° 28′.

In obtaining the latitudes of those places which are referred to the meridian of Greenwich, it is easy to perceive, that little error is introduced by spherical computation, since the spheroidical correction for the latitude of Bagshot Heath is only about $\frac{1}{100}$ of a second. Had indeed the latitudes of the stations, which are far to the westward, been computed with distances from the meridian, and the perpendicular at Greenwich, some small errors might have been introduced, from the uncertainty of the earth's figure, and the consequent inability of computing the spheroidical corrections with sufficient accuracy; but as the distance between the parallels of Beachy Head and Dunnose is obtained very nearly, the latitude of the latter station may be considered as correct as that of the former one, and consequently the places in the vicinity of Dunnose have their latitudes determined with sufficient precision.

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137. *Secondary Triangles, in which two Angles only have been observed. The first seven intersected Places were selected for interior Stations, on account of their commanding Situations.*

Triangles.	Angles observed.	Distances of the stations from the point intersected.	
	° ′ ″		Feet.
Beachy Head - Ditchling Beacon - *Firle Beacon*	10 19 30 8 53 23	Firle Beacon -	47956 55621
Chanctonbury Ring from the support of High Down Windmill 29442 feet.			
Chanctonbury Ring - High Down Windmill *Sleep Down*	64 54 52 79 3 33	Sleep down -	17637 27159
Butser Hill - Rook's Hill - *Bow Hill*	10 28 4 28 19 50	Bow Hill -	46150 17668
Butser Hill - Rook's Hill - *Portsdown Hill*	93 25 15 39 23 59	Portsdown Hill	52729 82926
Dunnose - - Motteston Down - *Thorness*	30 34 9 79 6 47	Thorness - *Isle of Wight*	57470 29764
Motteston Down - Nine Barrow Down *Ramsden Hill*	27 57 12 42 26 2	Ramsden Hill -	97051 67423
Dean Hill - Beacon Hill - *Stockbridge Hill*	71 10 48 51 45 47	Stockbridge Hill	54366 65515

With respect to these triangles, there is nothing to be remarked, except that the angles of the 1st and 3d, from their being very acute, were determined with considerable care: the distances, however, from Firle Beacon to Ditchling Beacon, and Beachy

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Head, may be ascertained, when either the great or small instrument are taken to that station, by the intersection of Hurstmonceux Spire.

Triangles formed by the Intersections of Churches, Windmills, and other objects.

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
			Feet.
Fairlight down - Brightling - *Bexhill Church*	48° 18′ 18″ 32 6 22	Bexhill Church *Sussex*	34 7 48294
Fairlight Down - Brightling - *Westham Church*	46 56 7 73 7 30	Westham Church	70511 53832
Fairlight Down - Brightling - *Pevensey Church*	46 46 20 71 21 47	Pevensey Church	68526 52694
Fairlight Down - Brightling - - *Blackheath Windmill (near Heathfield)*	4 34 13 154 19 13	Blackheath Wind-mill -	76733 14110
Fairlight Down - Brightling - *Ninefield Church* -	25 26 4 40 43 54	Ninefield Church	45493 29943
Fairlight Down - Brightling - *Mountfield Church*	10 32 37 16 44 22	Mountfield Church -	40071 25458
Beachy Head - Ditchling Beacon - *Hurstmonceux Church*	76 6 36 26 40 41	Hurstmonceux Church -	47021 101668
Ditchling Beacon - Crowborough Beacon *Chittingly Church* -	41 17 30 58 11 13	Chittingly Church	69950 54320

	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
		° ′ ″		Feet.
D	Ditchling Beacon Crowborough Beacon *Waldron Church*	13 23 46 65 34 25	Waldron Church	75316 19165
	Ditchling Beacon Crowborough Beacon *Firle Church*	67 16 28 36 30 43	Firle Church -	49742 77110
	Ditchling Beacon - Crowborough Beacon *Jevington Windmill*	70 32 0 58 49 56	Jevington Wind-mill -	89861 99016
	Ditchling Beacon - Crowborough Beacon *Plumpton Church*	34 14 48 3 37 4	Plumpton Church	8347 74441
D	Ditchling Beacon - Crowborough Beacon *Little Horstead Church*	23 34 6 28 0 42	Little Horstead Church -	48670 41436
	Ditchling Beacon - Crowborough Beacon *Spittal Windmill* -	66 41 33 14 29 24	Spittal Windmill	20558 75458
	Ditchling Beacon - Crowborough Beacon *Ditchling Church*	61 49 49 4 48 36	Ditchling Church	7416 77966
	Chanctonbury Ring Ditchling Beacon - *Thakeham Church*	115 19 36 13 56 34	Thakeham Church -	19754 74103
	Chanctonbury Ring Ditchling Beacon - *West Grinsted Church*	66 23 40 28 9 20	West Grinsted Church -	30044 58342
	Chanctonbury Ring Ditchling Beacon - *Keymer Church*	6 40 15 55 52 17	Keymer Church	59208 8309
	Chanctonbury Ring Ditchling Beacon - *Bolney Church*	37 47 12 57 3 58	Bolney Church	53461 39029

	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
	Chanctonbury Ring Ditchling Beacon *Slaugham Church* -	° ′ ″ 50 26 25 66 41 45	Slaugham Church -	65501 54985
D	Chanctonbury Ring Ditchling Beacon - *Starting House on the Race Ground near Brighthelmstone*	23 2 19 86 0 59	Starting House	66986 26279
	Chanctonbury Ring Ditchling Beacon - *Cuckfield Spire*	33 58 20 72 9 49	Cuckfield Spire	67789 38568
	Chanctonbury Ring Ditchling Beacon - *Wyvelsfield Church*	20 34 55 98 0 8	Wyvelsfield Church	71575 25409
D	Chanctonbury Ring Ditchling Beacon - *Hurstpierpoint Church*	14 32 35 36 29 25	Hurstpierpoint Church -	48545 20498
	Chanctonbury Ring Ditchling Beacon - *Lindfield Church*	29 51 47 100 41 5	Lindfield Church	82079 41590
D	Chanctonbury Ring Sleep Down - *Goring Church*	52 22 45 96 27 23	Goring Church	33866 26995
	Chanctonbury Ring Sleep Down - *Southwick Church*	22 46 56 140 53 45	Southwick Church - *Sussex*	39584 24302
	Chanctonbury Ring Sleep Down - *Shoreham Church*	14 28 30 151 0 0	Shoreham Church	34094 17578
	Chanctonbury Ring Sleep Down - *Brighthelmst. Church*	32 5 47 136 19 20	Brighthelmstone Church -	60672 46680
	Chanctonbury Ring Sleep Down - *Bramber Windmill*	43 9 25 83 16 48	Bramber Windmill - -	21772 14995

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Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
Chanctonbury Ring Sleep Down - *Temple in Findon Park*	88° 47′ 22″ 37 32 41	Temple in Findon Park -	13341 21889
Chanctonbury Ring Rook's Hill - *West Tarring Church*	82 19 10 17 41 21	West Tarring Church -	26426 86189
Chanctonbury Ring Rook's Hill - *Highdown Windmill*	56 47 5 19 30 39	High Down Windmill.	29442 73752
Canctonbury Ring Rook's Hill - D *Angmering Church*	45 44 35 21 55 49	Angmering Church - -	34579 66312
Chanctonbury Ring Rook's Hill - *Sir R. Hotham's Flag-staff, near Bersted*	30 40 1 68 36 53	Sir R. Hotham's Flagstaff -	80807 44263
Chanctonbury Ring Rook's Hill - *Bersted Church*	27 54 15 64 26 6	Bersted Church	77325 40115
Chanctonbury Ring Rook's Hill - - *Felpham Windmill*	31 22 33 60 52 32	Felpham Wind-mill -	74875 44626
Chanctonbury Ring Rook's Hill - D *Clapham Church*	44 29 25 16 3 16	Clapham Church *Sussex.*	27201 68929
Chanctonbury Ring Rook's Hill - *Oving Church*	14 12 22 71 6 26	Oving Church	81303 21089
Chanctonbury Ring Rook's Hill - *Pagham Church*	27 31 18 89 41 40	Pagham Church	96306 44502
Butser Hill - Rook's Hill - - *Lantern of the Vessel moored over the Ower Rocks*	26 55 45 134 6 0	Ower Rocks -	134605 84889

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Triangles.	Angles observed	Distances of the stations from the intersected objects.	
	° ′ ″		Feet.
Butser Hill - - Rook's Hill - - *Selsea Church*	27 45 25 117 47 2	Selsea Church -	95276 50154
Butser Hill - - Rook's Hill - *Selsea High House*	34 42 20 110 6 12	Selsea High House -	99290 60199
Butser Hill - - Rook's Hill - - *Selsea Windmill*	34 40 45 109 9 31	Selsea Windmill	97545 58756
Butser Hill - - Rook's Hill - - *Cackham Tower*	43 21 26 85 21 20	Cackham Tower	77835 53613
Butser Hill - - Rook's Hill - - *Bosham Church*	32 2 23 74 11 15	Bosham Church	61061 33667
Butser Hill - - Rook's Hill - - *Princested Windmill*	43 28 50 57 30 20	Princested Windmill - -	52354 42712
Butser Hill - - Rook's Hill - - *Del Key Windmill*	25 41 30 92 32 2	Del Key Windmill -	69090 29981
Butser Hill - - Rook's Hill - - *West Thorney Church*	43 30 10 68 27 23	West Thorney Church -	61110 45227
Butser Hill - Rook's Hill - - *South Hayling Church*	58 31 52 65 13 29	South Hayling Church -	66544 62510
Butser Hill - - Rook's Hill - - *Bourn Church*	43 27 20 46 55 22	Bourn Church -	44509 41911
Butser Hill - - Rook's Hill - - *Flagstaff at the Watch-house near Chichester Harbour*	49 48 19 75 49 16	Flagstaff -	72681 57262

Triangles.	Angles observed.	Distances of the stations from intersected objects.	
	° ′ ″		Feet.
Butser Hill - - Rook's Hill - *Clark's Folly*	69 28 9 44 0 16	Clark's Folly -	46151 62212
Butser Hill - - Rook's Hill - *Portsdown Windmill*	83 38 24 41 29 17	Portsdown Windmill - -	49356 74045
Butser Hill - - Rook's Hill - - *West Chimney on the Governor's House, Cumberland Fort*	69 19 25 61 5 43	Cumberland Fort	70049 74863
Butser Hill - - Rook's Hill - *South Sea Castle*	78 14 54 59 2 32	South Sea Castle	77038 87953
Butser Hill - - Rook's Hill - *St. Cath. Light House*	87 18 4 71 26 30	St. Catherine's Light House *Isle of Wight*	159328 167881
Butser Hill - - Rook's Hill - - *Sir R. Worsley's Obelisk*	84 30 52 72 3 59	Sir R. Worsley's Obelisk - *Isle of Wight*	145861 152608
Butser Hill - - Rook's Hill - - *Ashey Down Sea Mark*	83 29 28 67 44 36	Ashey Down Sea Mark - *Isle of Wight*	117188 125806
Butser Hill - - Rook's Hill - - *Flagstaff of Cowes Fort*	103 12 19 50 10 44	Flagstaff, Cowes Fort - - *Isle of Wight*	104463 132415
Butser Hill - Rook's Hill - - *Summer House of the Horse-shoe Inn above Cowes*	100 21 10 54 17 51	Summer House	115573 140005
Butser Hill - - Rook's Hill - - *Needles Light House*	109 32 45 54 19 57	Needles Light House - *Isle of Wight*	178277 206796

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
	° ′ ″		Feet.
Butser Hill - Dean Hill - *Southampton Spire*	23 25 47 32 58 47	Southampton Spire - -	102010 74522
Rook's Hill - - Bow Hill - - *Box Grove Church*	132 28 11 21 57 31	Box Grove Church	15306 30194
Rook's Hill - - Bow Hill - - *Portfield Windmill*	87 10 9 47 44 17	Portfield Windmill	18462 24916
Rook's Hill - - Bow Hill - - *North-west Chimney on Goodwood House*	116 1 21 18 38 9	Goodwood House	7938 22321
Rook's Hill - - Bow Hill - *Chichester Spire*	75 29 10 59 11 56	Chichester Spire	21345 24057
Rook's Hill - - Hind Head - - *Sir H. Fetherstonhaugh's Tower*	57 8 41 27 50 34	Sir H. Fetherstonhaugh's Tower	38424 69110
Rook's Hill - - Hind Head - *Windmill near Rook's Hill*	122 22 23 2 1 34	Windmill near Rook's Hill -	3512 83887
Rook's Hill - - Hind Head - - *Harting Windmill*	53 56 49 25 52 2	Harting Windmill - -	36328 67319
Chanctonbury Ring Hind Head - *Petworth Spire*	13 43 52 16 16 36	Petworth Spire	62080 52576
Chanctonbury Ring Hind Head - *Wisborough Green Church*	12 50 23 11 28 10	Wisborough Green Church	53508 59799

D

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
	° ′ ″		Feet.
Chanctonbury Ring Hind Head - *Kirdford Church*	5 12 39 6 29 12	Kirdford Church	61725 49623
Chanctonbury Ring Hind Head - *Billinghurst Church*	24 48 50 16 58 51	Billinghurst Church	48543 69755
Chanctonbury Ring Hind Head - *Rusper Church*	59 43 43 47 42 51	Rusper Church	85901 100281
Chanctonbury Ring from Butser Hill 141003 feet.			
Chanctonbury Ring Butser Hill - *The Earl of Egremont's Tower, near Petworth*	20 22 27 18 0 51	The Earl of Egremont's Tower	70219 79052
Chanctonbury Ring Butser Hill - D *Pulborough Church*	25 12 40 8 5 46	Pulborough Church	36163 109375
Leith Hill - - Hind Head - *St. Martha's Chapel*	41 32 40 27 9 5	St. Martha's Chapel - - *near Guildford*	40257 58505
Leith Hill - - Hind Head - *Euhurst Windmill*	11 39 40 3 49 39	Euhurst Windmill	20544 62206
Leith Hill - - Hind Head - *Euhurst Church*	12 25 16 3 27 43	Euhurst Church	18135 64596
Leith Hill - - Hind Head - *Norris's Obelisk, Bagshot Heath*	51 3 46 77 52 38	Norris's Obelisk	103310 82191
Leith Hill - - Hind Head - *Horsham Spire*	86 36 23 28 38 34	Horsham Spire	43558 90710

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Triangles.	Angles observed. ° ′ ″	Distances of the stations from the intersected objects.	Feet.
Leith Hill - Hind Head - *Farnham Castle*	24 34 44 101 49 30	Farnham Castle	99948 42474
Leith Hill - Ditchling Beacon *Beddingham Windmill*	7 38 23 152 37 54	Beddingham Windmill -	159594 46153
Leith Hill - Ditchling Beacon *Firle Windmill*	9 19 46 149 13 1	Firle Windmill	163984 51942
Leith Hill - Crowborough Beacon D *West Hoatbly Church*	6 9 46 10 22 53	West Hoathly Church -	81212 48382
Crowborough Beacon from Fairlight Down 125303 feet.			
Crowborough Beacon Fairlight Down - *Willington Church*	45 4 32 43 6 42	Willington Church -	85678 88764
Crowborough Beacon Brightling - *Homeburst Church*	12 21 46 70 18 45	Homehurst Church -	58474 13297
Crowborough Beacon Brightling - *Hailsbam Church*	37 38 24 85 39 48	Hailsham Church	73490 45009
Crowborough Beacon Brightling - *Dallington Church*	6 25 16 83 32 52	Dallington Church -	61208 6889
Crowborough Beacon Botley Hill *East Grinsted Church*	31 6 44 24 17 45	East Grinsted Church -	44729 56173
Crowborough Beacon Botley Hill - *Fairden Tower*	17 4 46 18 51 52	Fairden Tower	49295 44777
Crowborough Beacon Botley Hill - *Crowborough Chapel*	93 16 22 2 3 11	Crowborough Chapel -	3220 89734

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Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
	° ′ ″		Feet.
Crowborough Beacon Botley Hill - *Rotherfield Spire*	121 34 38 7 42 43	Rotherfield Spire	15517 98509
Crowborough Beacon Botley Hill - *Mayfield Spire*	137 42 2 9 35 19	Mayfield Spire	27585 111453
Crowborough Beacon Botley Hill - *Bestbeech Windmill*	108 47 35 18 39 16	Bestbeech Wind- mill - -	36056 106714
Crowborough Beacon Botley Hill - *Tatesfield Church*	5 2 39 90 24 37	Tatesfield Church	89897 7904
Botley Hill - Leith Hill - - D *Charlwood Church*	17 5 35 36 33 33	Charlwood Church -	68505 33804
Botley Hill - Leith Hill - - D *Evelyn's Obelisk*	54 41 39 33 25 22	Evelyn's Obelisk	51051 75636
Butser Hill - - Hind Head - *Petworth Windmill*	36 49 10 83 42 37	Petworth Wind- mill -	91054 54899
Portsdown Hill - Butser Hill - - *Southwick Church*	41 34 33 4 31 23	Southwick Church *Hants.*	5771 48564
Dunnose - - Butser Hill - *Flagstaff of Carisbrook Castle*	67 7 31 14 59 6	Flagstaff, Caris- brook Castle -	36697 130763
Dunnose - - Butser Hill - *Lord Halifax's Tower*	15 4 28 49 11 35	Halifax Tower -	118122 40586

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Portsdown Hill from Dunnose 90007 feet.

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
	° ′ ″		Feet.
Portsdown Hill - Dunnose - - *Kingston Church, Portsea Island*	33 53 34 9 20 28	Kingston Church	21328 73274
Portsdown Hill - Dunnose - - D *Horndean Church*	150 33 55 7 45 58	Horndean Church	33430 120320
Dunnose - - Motteston Down - *East Corner of the Roof of the great Boat House at the Back of the Isle of Wight*	12 13 22 35 10 30	Great Boat House	43127 15849
Dunnose - - Motteston Down - *Brixton Church, Isle of Wight*	5 3 4 25 53 6	Brixton Church	46795 9437
Dunnose - - Motteston Down - *East Cowes Sea Mark, Isle of Wight*	54 23 57 62 29 15	East Cowes Sea Mark - -	54796 50235
Dunnose - - Motteston Down - *Luttrell's Folly*	50 34 24 82 14 9	Luttrell's Folly	74424 58020
Dunnose - - Motteston Down - *Fawley Church*	48 58 19 90 32 45	Fawley Church	84875 64032
Dunnose - - Motteston Down - *Flagstaff, Calshot Cast.*	54 43 0 80 53 17	Flagstaff, Calshot Castle - -	77771 64296
Dunnose - - Motteston Down - *Fareham Church*	77 13 3 66 57 30	Fareham Church	86636 91814

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
			Feet.
Dunnose - - Motteston Down - *Porchester Church*	87° 30′ 58″ 57 50 55	Porchester Church -	82086 96863
Dunnose - - Motteston Down - *Hamble Church*	56 5 32 87 4 16	Hamble Church	91792 76281
Dunnose - - Motteston Down - *Hamble Saltern* -	56 40 50 84 55 52	Hamble Saltern	88390 74150
Dunnose - - Motteston Down - *Gov. Hornby's House, Centre Pediment*	57 49 18 82 52 7	Gover. Hornby's House -	86309 73621
Dunnose - - Motteston Down - *Warblington Church*	106 36 6 48 57 49	Warblington Church -	100482 127660
Dunnose - - Motteston Down - *Bursledon Windmill*	58 39 40 89 30 11	Bursledon Wind-mill -	104462 89225
Dunnose - - Motteston Down - *Porchester Castle*	87 8 20 58 16 27	Porchester Castle	82568 96952
Dunnose - - Motteston Down - *Havant Church*	104 5 1 50 25 55	Havant Church	98725 124221
Dean Hill - - Four Mile-stone - *Winterslow Church*	42 54 34 21 6 1	Winterslow Church -	22739 43004
Dean Hill - - Dunnose - - *Farley Monument*	60 20 37 16 44 23	Farley Monument	53239 160629
Motteston Down - Nine Barrow Down *Hordle Church*	33 29 46 16 13 59	Hordle Church	49640 98000

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Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
	° ′ ″		Feet.
Motteston Down - Nine Barrow Down *Milford Church*	36 52 51 15 13 46	Milford Church	45098 103035
Motteston Down - Nine Barrow Down *Hurst Light House*	33 17 31 9 49 13	Hurst Light House -	33813 108820
Motteston Down - Nine Barrow Down - *Hurst Castle*	33 32 2 9 48 47	Hurst Castle -	33564 109043
Motteston Down - Nine Barrow Down - *Cupola of Sir J. Doyley's House*	67 18 34 20 13 51	Sir J. Doyley's House -	46896 125118
Motteston Down - Nine Barrow Down - *Milton Abbey Church*	34 4 47 23 22 56	Milton Church	63782 90057
Motteston Down - Nine Barrow Down - *North Chimney on Lord Bute's House*	27 1 16 24 13 18	Lord Bute's House	71283 78937
Motteston Down - Nine Barrow Down - *Centre Pediment of Belvidere House*	28 48 39 25 29 50	Belvidere House	71813 80396
Dean Hill - - Motteston Down - *Summer House on Kilminston Down*	66 5 5 44 20 32	Summer House Kilminston Down	107978 141217
Nine Barrow Down - Black Down - *Poole Church*	89 46 55 13 3 59	Poole Church	29399 130037
Nine Barrow Down - Black Down - - *Fordington Church*	7 54 30 28 11 54	Fordington Church -	101661 29601

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Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
Nine Barrow Down Black Down - *Dorchester Church*	° ′ ″ 7 54 33 30 35 42	Dorchester Church -	103647 28022
Nine Barrow Down Black Down - - *Wyke Church, near Weymouth*	15 28 23 54 29 40	Wyke Church	109854 36002
Nine Barrow Down Wingreen - - *Obelisk near Milbourn St. Andrew's*	41 50 35 35 56 53	Obelisk near Milbourn -	78218 88882
Nine Barrow Down Wingreen - - *Mr. Trenchard's Tower near Lytchet*	12 9 2 9 3 17	Mr. Trenchard's Tower -	56660 75778
Nine Barrow Down Wingreen - - *Flagstaff, Mr. Pitt's Factory, Isle of Purbeck.*	113 10 7 5 30 19	Flagstaff, Mr. Pitt's Factory	14240 136456
Nine Barrow Down Wingreen - - *Centre of the Barrow on Creech Hill, Isle of Purbeck*	73 32 14 10 38 14	Barrow on Creech Hill -	24163 125534
Nine Barrow Down Wingreen - - *Vane on the Castle, Branksea Island*	40 45 31 7 37 13	Branksea Castle	23101 113731
Nine Barrow Down Wingreen - - *Horton Observatory*	18 12 9 27 4 38	Horton Observatory -	83424 57250
Nine Barrow Down Wingreen - - *Staircase of Alfred's Tower, in Stourhead Park*	14 51 23 138 58 56	Alfred's Tower -	193843 75729

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
	° ′ ″		Feet.
Nine Barrow Down Wingreen - D *Ringwood Church*	42 27 24 45 8 30	Ringwood Church	92391 87983
Nine Barrow Down Wingreen - - D *Summer House at Moyle's Court*	41 55 41 53 51 18	Summer House, Moyle's Court	105698 87461
Nine Barrow Down Wingreen - - *Christchurch Tower*	66 36 0 29 45 57	Christchurch -	65052 120256
Nine Barrow Down Wingreen - - *Warren Summer House, Christchurch Head*	72 43 29 29 13 29	Warren Summer-House - -	64989 127104
Wingreen from Blackdown 149140 feet.			
Wingreen - - Blackdown - *Barrow, Swyre Head, Isle of Purbeck*	44 36 0 62 1 41	Swyre Head -	137466 109289
Motteston Down from Wingreen 197090 feet.			
Motteston Down - Wingreen - - D *Sopley Church*	11 6 40 10 13 47	Sopley Church -	96183 104370
Dean Hill - - Beacon Hill - *Salisbury Spire*	53 21 33 35 37 6	Salisbury Spire -	33834 46615
Beacon Hill - - Four Mile-stone - *Altar-piece at Stone Henge*	33 20 34 34 52 8	Altar-piece at Stone Henge	23900 22978
Beacon Hill - - Four Mile-stone - *Amesbury Church*	20 44 17 11 52 14	Amesbury Church	14817 25506

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Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
			Feet.
Beacon Hill - - Four Mile-stone - *South Chimney on Old Hartford Hut, Salisbury Plain*	16° 26′ 51″ 56 13 33	Old Hartford Hut	33801 11513
Beacon Hill - - Four Mile-stone - *Everley Church*	132 24 37 23 7 41	Everley Church	36822 69215
Beacon Hill - - Four Mile-stone - *Summer House on Martincel's Hill, near Marlborough*	119 35 33 39 11 38	Summer House on Martincel's Hill	67794 93285
Beacon Hill - - Four Mile-stone - *North Windmill, Salisbury Plain*	45 4 20 81 52 17	North Windmill	48082 34387
Beacon Hill - - Four Mile-stone - *South Windmill, Salisbury Plain*	41 55 52 74 6 39	South Windmill	41554 28871
Beacon Hill - - Wingreen - - *Clay Hill Barrow, near Warminster*	42 46 45 70 18 36	Clay Hill Barrow, or Copt Heap -	117216 84554

Triangles for finding the distance of Portsmouth Observatory from Dunnose.

Dunnose - - Motteston Down - *Spindle of the Wind Vane on Portsmouth Church Tower*	92 44 48 48 44 27	Portsmouth Church -	66524 88393

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
	° ′ ″		Feet.
Dunnose - -	91 35 32	Portsmouth Academy - -	69787
Motteston Down -	50 43 36		90113
Ball of the Cupola of Portsmouth Academy			

In order to ascertain the situation of the Observatory, Mr. Bayly, Master of the Academy, measured two angles in the following triangle, *viz.*

	°	′	″
Portsmouth Academy	124	9	15
Observatory -	53	6	15
Portsmouth Church			

The included angle at Dunnose between the Ball on the Cupola of the Academy, and the Spindle of the Wind Vane on Portsmouth Church, is 1° 9′ 16″, and the distances of those objects from Dunnose are 66524 and 69787 feet; therefore the distance between the Academy and the Church will be 3540 feet: this distance, used as a base in the above triangle, gives the distance between the Observatory and the Church 3663 feet; now the angle at the Church, comprehended by the Academy and the Observatory, being 2° 44′ 30″, we shall find the angle at Dunnose, between Portsmouth Church and the Observatory, to be 1° 3′ 30″, and the distance of the Observatory from Dunnose 69962 feet.

Remarks.

In an operation of this kind, it naturally follows, when the objects intersected are at considerable distances from the stations, there must be great difficulty in ascertaining their precise situations from the appearance of the country. Under such circumstances their names sometimes cannot be discovered; and it has

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been found, that the best maps of which we are in possession, were by no means sufficiently correct to be of much service in that particular. It is obvious also, without a very intimate knowledge of the interior parts of the country (of which it is impossible, in the present state of the Survey, we can be altogether possessed), there must be some difficulty to identify them, when their distances exceed twelve or fourteen miles. We have, therefore, when such an uncertainty existed, had recourse to some intelligent person well acquainted with the country, by whom we have been informed of their names. In this respect we have to acknowledge the services of Mr. Gardner, chief Draftsman at the Tower, by whose assistance, from his intimate knowledge of the county of Sussex, we have been able to determine, with certainty, the names of many places, which we might otherwise have considered as doubtful. Of the triangles here given, there is not much reason to believe there has been any misnomer; but, as there is not altogether a certainty that all are rightly named, or the objects actually intersected, we have prefixed a D to those we consider as doubtful.

It may be proper to observe, that in taking the angles, the most defined parts of the objects have been selected, unless they were church towers without spires or pyramidical roofs, when the angles were taken to the middles of the towers. If the objects were windmills, resting (as they sometimes do) on great spindles, the observations have been made to those spindles; but in other cases, when the supports were undefined, the mills themselves were intersected.

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Distances of the Objects intersected in the Course of the Survey, from the Meridians of Greenwich, Beachy Head, and Dunnose, respectively; and from the Perpendiculars to those Meridians; with their Bearings at the several Stations, from the Parallels to the Meridians.

138. Meridian of Greenwich.

Bearings from the Parallels to the Meridian.					Distances from merid.	Distances from perp.
At Brightling.	°	′	″		Feet.	Feet.
Bexhill Church - -	29	19	25	SE	110956	230225
Westham Church -	11	41	43	SW	76392	240833
Pevensey Church - -	9	56	0	SW	78214	240023
Black Heath Windmill -	87	6	34	NW	73212	187407
Ninefield Church -	20	41	53	SE	97887	216129
Mountfield Church -	78	10	9	SE	112221	193338
At Ditchling Beacon.						
Chittingly Church -	88	37	2	NE	45462	208569
Waldron Church -	60	43	18	NE	41227	173423
Firle Beacon Station -	63	33	11	SE	25332	235029
Firle Church - -	65	24	0	SE	20759	230963
Jevington Windmill -	62	8	28	SE	54978	252248
Plumpton Church -	81	34	20	NE	16211	209034
Little Horsted Church -	70	53	38	NE	21521	194326
Spittal Windmill -	65	58	55	SE	5690	218625
Ditchling Church -	14	30	17	NW	26325	203077
Thakeham Church -	77	33	40	NW	96831	194295
West Grinsted Church -	63	20	56	NW	76612	184087
Keymere Church -	35	37	57	NW	29309	203504
Bolney Church - -	34	26	16	NW	46539	178068
Slaugham Church - -	24	48	29	NW	47538	160346
Starting House, Brighton	2	28	47	SW	25605	236511
Cuckfield Church - -	12	20	25	NW	32711	172580
Wyvelsfield Church -	6	29	54	NE	21592	185011
Hurstpierpoint Church -	55	0	49	NW	41262	198504
Lindfield Church -	9	10	51	NE	17832	169199

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Bearings from the Parallels to the Meridian.		Distances from merid.	Distances from perp.
At Crowborough Beacon.	° ′ ″	Feet.	Feet.
Willington Church -	14 31 53 SE	56724	238159
Homehurst Church -	70 4 58 SE	90204	175142
Hailsham Church -	20 4 48 SE	60458	224245
Dallington Church -	51 17 56 SE	82994	193493
At Botley Hill.			
East Grinsted Church -	1 14 6 SW	1039	129041
Rotherfield Church -	30 46 22 SE	50573	157520
Mayfield Church -	32 38 58 SE	60300	166723
Crowborough Chapel -	25 6 50 SE	38257	154132
Bestbeech Windmill -	41 42 55 SE	71183	152539
Fairden Tower - -	4 11 47 SE	3448	117538
Tatesfield Church -	66 31 44 NE	7422	69733
Charlwood Church -	49 25 48 SW	51866	117435
Evelyn's Obelisk - -	11 49 44 SW	10294	122847
At Leith Hill.			
Firle Windmill -	40 18 35 SE	21292	234831
Beddingham Windmill -	38 37 12 SE	14819	234476
Horsham Church - -	11 54 25 SE	75805	152405
Farnham Castle - -	80 43 18 NW	183432	93669
Euhurst Windmill - -	86 21 38 SW	195295	111088
Euhurst Church -	62 16 42 SW	100845	118215
St. Martha's Chapel -	63 45 21 NW	120899	91983
Norris's Obelisk (Bagshot Heath) - -	54 14 15 NW	168622	49407
West Hoathly Church -	63 6 5 SE	12367	146525
Nettlebed - - -	43 12 55 NW	224159	38548
At Beachy Head.			
Hurstmonceux Church -	21 26 48 NE	76041	225562

139. Meridian of Beachy Head.

At Chanctonbury Ring.			
Sleep Down - -	32 8 34 SE	137183	42974
Brighthelmstone Church -	64 14 21 SE	91925	31539

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Bearings from the Parallels to the Meridian.			Distances from merid.	Distances from perp.
At Chanctonbury Ring.	° ′ ″		Feet.	Feet.
Shoreham Church - -	46 37 4	SE	121788	34490
Southwick Church -	54 55 30	SE	114171	35161
Goring Church -	20 14 11	SW	158281	26132
Bramber Windmill -	75 17 59	SE	125507	52383
Findon Temple - -	56 38 48	SW	157711	50573
140. Meridian of Dunnose.				
At Hind Head.				
Petworth Church -	28 4 40	SE	135688	135394
Kirdford Church -	50 50 28	SE	149419	150447
Wisborough Green Church	55 49 26	SE	160414	148101
Billinghurst Church -	61 20 7	SE	172148	148322
Rusper Church - -	87 55 49	NE	211158	185404
At Butser Hill.				
Pulborough Church -	86 21 25	SE	159482	124313
Earl of Egremont's Tower	83 43 30	NE	128906	139903
Bosham Church -	27 20 55	SE	78379	77027
Selsea Church - -	31 37 53	SE	100296	50141
Prinsted Windmill -	15 54 28	SE	64678	80914
Del Key Windmill -	33 41 48	SE	88659	73781
Horse-shoe Summer House	41 57 52	SW	26952	45327
Southampton Spire -	73 45 14	SW	47618	102722
Selsea Windmill -	24 42 33	SE	91103	42649
Flagstaff, Chichester Harbour - -	9 34 59	SE	62428	59596
Cackham Tower -	16 1 52	SE	71823	56455
Selsea High House -	24 40 58	SE	91791	41045
Bourn Church -	15 55 58	SE	62546	88464
Ower Rocks - -	32 27 33	SE	122570	17687
South Hayling Church -	0 51 26	SE	51324	64727
West Thorney Church -	15 53 8	SE	67055	72486
Bow Hill Station - -	48 55 14	SE	85116	100937
St. Catharine's Light House	27 54 46	SW	24258	9529
Needles Light House -	50 9 27	SW	86554	17045

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Bearings from the Parallels to the Meridian.		Distances from merid.	Distances from perp.
At Butser Hill.	° ′ ″	Feet.	Feet.
Worseley's Obelisk - -	25 7 34 SW	11607	796
Ashey Down Sea Mark -	24 6 10 SW	2471	24292
Cowes Fort - -	43 49 1 SW	21998	55887
Portsdown Windmill -	24 15 6 SW	30055	86262
Clark's Folly - -	10 4 51 SW	42250	85825
South Sea Castle -	18 51 36 SW	25425	58361
Portsdown Hill Station -	34 2 0 SW	20816	87565
Petworth Windmill -	87 0 38 NE	141258	136012
At Rook's Hill.			
West Tarring Church -	73 52 32 SE	185568	76299
High Down Windmill -	72 3 14 SE	172934	77511
Angmering Church -	69 38 4 SE	164937	77159
Pagham Church - -	1 25 13 SE	104222	55757
Bersted Church - -	27 7 47 SE	121063	64535
Clapham Church - -	75 30 37 SE	169507	82990
Oving Church - -	20 27 27 SE	110141	80477
Felpham Windmill -	30 41 22 SE	125546	61860
Boxgrove Church - -	40 11 21 SE	112647	88543
Goodwood House - -	23 44 31 SE	105966	92970
Portfield Windmill -	5 6 41 SW	101125	81847
Chichester Spire - -	16 47 40 SW	96603	79801
Harting Windmill - -	48 13 28 NW	75678	124438
Sir H. Fetherstonhaugh's Tower - -	51 25 10 NW	72732	124196
Sir R. Hotham's Flagstaff	22 57 0 SE	120029	59477
At Dunnose.			
Kingston Church - -	22 42 52 NE	28294	67591
Horndean Church -	21 8 22 NE	43392	112223
Porchester Castle - -	13 33 12 NE	19350	80269
Halifax Tower - -	36 3 7 NE	69517	95499
Carisbrook Castle -	46 10 52 NW	26478	25408
Thorness Station -	43 0 59 NW	39207	42020
Luttrell's Folly - -	23 0 44 NW	29094	68502
Great Boat House -	85 48 30 NW	43011	3152

Bearings from the Parallels to the Meridian.		Distances from merid.	Distances from perp.
At Dunnose.	° ′ ″	Feet.	Feet.
Brixton Church - -	78 38 12 NW	45878	9220
Calshot Castle - -	18 52 8 NW	25151	73592
Fawley Church - -	24 36 49 NW	35350	77163
East Cowes Sea Mark -	19 11 11 NW	18008	51752
Bursledon Windmill -	14 55 28 NW	26904	100938
Hamble Church - -	17 29 36 NW	27592	87546
Hamble Saltern - -	16 54 18 NW	25702	84570
Governor Hornby's House	15 45 50 NW	23448	83063
Warblington Church -	33 0 58 NE	54750	84255
Farley Monument -	18 0 4 NW	49640	152765
Portsmouth Church -	19 9 40 NE	21835	62839
——— Academy -	18 0 24 NE	21573	66369
——— Observatory	18 6 10 NE	21739	66499
Fareham Church - -	3 37 55 NE	5488	86462
Porchester Church -	13 55 50 NE	19762	79672
Havant Church - -	30 29 53 NE	50104	85066
At Dean Hill.			
Salisbury Spire - -	68 52 9 NW	136127	162983
Stockbridge Hill Station	55 40 12 NE	59673	181446
Winterslow Church -	12 5 5 NW	109329	173021
At Four Mile-stone.			
N. Windmill, Salisbury Plain	21 11 6 NW	161506	210275
S. Windmill, Salisbury Plain	28 56 44 NW	167717	213446
At Motteston Down.			
Ramsden Hill Station -	65 47 6 NW	141369	55377
Hordle Church - -	60 14 32 NW	95952	40210
Milford Church - -	56 51 27 NW	90619	40228
Milton Church - -	59 39 31 NW	107904	47792
Hurst Light House -	60 26 47 NW	82272	32250
Hurst Castle - -	60 12 16 NW	81985	32249
Lord Bute's House -	66 43 2 NW	118336	43747
Summer House, Kilminston Down - -	23 24 52 NE	3259	145161

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Bearings from the Parallels to the Meridian.		Distances from merid.	Distances from perp.
At Motteston Down.	° ′ ″	Feet.	Feet.
Sir J. Doyley's House -	26 25 44 NW	73731	57566
Belvidere House - -	64 55 39 NW	117904	46004
Sopley Church - -	63 44 46 NW	139119	58118
At Nine Barrow Down.			
Wyke Church - -	84 7 0 SW	297337	4524
Horton Observatory -	8 43 26 NE	175408	89196
Branksea Castle - -	31 16 48 NE	176067	26479
Sywre Head - -	65 41 52 SW	208018	2275
Ringwood Church -	32 58 41 NE	137771	84242
Moyle's Court Summer House - -	32 26 58 NE	131348	95932
Christchurch Tower -	57 7 17 NE	133429	42051
Christchurch Head -	63 14 46 NE	130030	35992
Poole Church - -	9 22 18 NE	183274	35743
Pitt's Factory - -	57 21 10 SW	200051	945
Creech Barrow - -	83 0 57 NW	212045	9675
Mr. Trenchard's Tower	21 37 45 NW	208946	59407
Obelisk, near Milbourn	51 19 18 NW	249123	55619
Fordington Church -	72 30 7 NW	285016	37303
Dorchester Church -	72 30 4 NW	286911	37901
Alfred's Tower - -	24 20 6 NW	267938	183357
At Beacon Hill.			
Amesbury Church -	73 39 50 SW	134320	202589
Summer House, Martincel's Hill - -	7 28 54 NW	128928	273974
Everley Church - -	5 20 10 NE	116677	243419
Stone Henge - -	86 16 7 SW	143950	205202
Old Hartford Hut -	69 22 24 SW	151735	194850
Clay Hill, or Copt Heap	85 54 8 NW	237017	215133

The bearings of the objects from the parallels to the meridians at the different stations, are inserted in the above table, in order that the numbers in the two last columns may be examined with greater

facility. The method of obtaining them is similar to that in Art. 59. and 130, thus:

At Beacon Hill, the bearing of Clay Hill is 85° 54′ 8″ NW; this, with the distance between Beacon Hill and Clay Hill, give 116916, and 8376 feet, for the distances of the latter place from the parallels to the meridian of Dunnose, and its perpendicular. But the distances of Beacon Hill from that meridian, and perpendicular, are 120101 feet, and 206757 feet; therefore $120101 + 116916 = 237017$ feet, and $206757 + 8376 = 215133$ feet, are the distances of Clay Hill from the meridian of Dunnose, and its perpendicular.

Latitudes and Longitudes of the intersected Objects.

141. *Latitudes and Longitudes of such Places upon the Sea Coast, and near it, as have been referred to the Meridian of Greenwich.*

Names of objects.	Latitude.	Longitude from Greenwich. In degrees.		Longitude from Greenwich. In time.
	° ′ ″	° ′ ″		m. s.
Bexhill Church -	50 50 46.7	0 28 43.3	E	1 54.9
Pevensey Church -	50 49 11.9	0 20 14.1	E	1 20.9
Westham Church -	50 49 4	0 19 45.8	E	1 19
Willingdon Church -	50 49 31.2	0 14 40.6	E	0 58.7
Jevington Windmill -	50 47 12.3	0 14 12.8	E	0 56.9
Firle Beacon Station	50 50 2.7	0 6 33.3	E	0 26.2
Firle Windmill -	50 50 4.8	0 5 30.6	E	0 22
Firle Church - -	50 50 42.9	0 5 22.4	E	0 21.5
Beddingham Windmill	50 50 8.3	0 3 50.1	E	0 15.3
Hailsham Church -	50 51 48.2	0 15 39.3	E	1 2.6
Spittal Windmill -	50 52 44.7	0 1 28.3	W	0 26
Starting House, Brighton	50 49 48.1	0 6 28.5	W	0 25.9

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142. *Latitudes and Longitudes of such Places upon the Sea Coast, and near it, as have been referred to the Meridian of Beachy Head.*

Names of objects.	Latitude.	Longitude west of Beachy Head.	Longitude west of Greenwich.	
			In degrees.	In time.
	° ′ ″	° ′ ″	° ′ ″	m. s.
Brighthelmstone Church - -	50 49 32.2	0 27 7.1	0 11 55.2	0 47.7
Southwick Church (*Sussex*) -	50 50 6.6	0 29 32.8	0 14 20.9	0 57.3
Shoreham Church - -	50 49 59.5	0 31 31	0 16 19.1	1 5.3
Bramber Windmill - -	50 52 55.7	0 32 30.8	0 17 18.9	1 9.3
Sleep Down Station - -	50 51 22.1	0 35 31.1	0 20 19.2	1 21.3
Goring Church - - -	50 48 34.2	0 40 56.5	0 25 44.6	1 43
Findon Temple - - -	50 52 15	0 40 50.8	0 25 38.9	1 42.6

143. *Latitudes and Longitudes of such Places upon the Sea Coast, and near it, as have been referred to the Meridian of Dunnose.*

Names of objects.	Latitude.	Longitude from Dunnose.	Longitude west of Greenwich.	
			In degrees.	In time.
	° ′ ″	° ′ ″	° ′ ″	m s.
West Tarring Church - -	50 49 29.8	0 48 1 E	0 23 35	1 34.3
High Down Windmill - -	50 49 42.9	0 44 45 E	0 26 51	1 47.4
Clapham Church - -	50 50 37.3	0 43 52.6 E	0 27 43.4	1 50.9
Angmering Church - -	50 49 40.3	0 42 40.8 E	0 28 55.2	1 55.7
Felpham Windmill - -	50 47 12.7	0 32 27.6 E	0 39 8.4	2 36.6
Bersted Church - -	50 47 39.4	0 31 18.2 E	0 40 17.8	2 41.2
Gov. Hornby's House - -	50 50 46.1	0 6 4.2 W	1 17 40.2	5 10.7
Sir R. Hotham's Flagstaff -	50 46 49.6	0 31 1.7 E	0 40 34.3	2 42.3
Oving Church - -	50 50 17.3	0 28 30.4 E	0 43 5.6	2 52.4
Pagham Church - -	50 46 14	0 26 56.1 E	0 44 39.9	2 58.7
Chichester Spire - - -	50 50 11.4	0 25 0.1 E	0 46 35.9	3 6.4
Selsea Church - - -	50 45 18.8	0 25 54.7 E	0 45 41.3	3 2.7
Selsea High House - -	50 43 49.6	0 23 42.2 E	0 47 53.8	3 11.5
Selsea Windmill - -	50 44 5.4	0 23 31.6 E	0 48 4.4	3 12.3
Del Key, or Dalkey Windmill -	50 49 12.5	0 22 56.3 E	0 48 39.7	3 14.6
Bosham Church - -	50 49 45	0 20 16.9 E	0 51 19.1	3 25.3
Cackham Tower - -	50 46 22.4	0 18 33.7 E	0 53 2.3	3 32.2
West Thorney Church -	50 49 0.7	0 17 20.8 E	0 54 15.2	3 37
Prinsted Windmill - -	50 50 23.9	0 16 44.4 E	0 54 51.6	3 39.4
Watch House, Chichester Harbour	50 46 53.8	0 16 8.3 E	0 55 27.7	3 41.8
West Bourn Church - -	50 51 38.4	0 16 11.7 E	0 55 24.3	3 41.6
Warblington Church - -	50 50 57.1	0 14 10.4 E	0 57 25.6	3 49.7
South Hayling Church - -	50 47 44.7	0 13 16.1 E	0 58 19.9	3 53.3
Clark's Folly - -	50 51 13	0 10 56.3 E	1 0 39.7	4 2.6

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Names of objects.	Latitude.	Longitude from Dunnose.	Longitude west of Greenwich. In degrees.	In time.
	° ′ ″	° ′ ″	° ′ ″	m. s.
Cumberland Fort - -	50 47 20.8	0 9 53.2 E	1 1 43	4 6.9
Kingston Church - -	50 48 13.5	0 7 19.1 E	1 4 16.9	4 17.1
Havant Church - -	50 51 5.4	0 12 58.3 E	0 58 37.7	3 54 5
Portsdown Windmill - -	50 51 17.6	0 7 46.9 E	1 3 49.1	4 15.3
Portsdown Station - -	50 51 30.6	0 5 23.4 E	1 6 12.6	4 24.8
Portsmouth Church - -	50 47 26.8	0 5 38.7 E	1 5 57.3	4 23.8
Portsmouth Academy - -	50 48 1.6	0 5 34.7 E	1 6 1.3	4 24.1
Portsmouth Observatory -	50 48 2.9	0 5 37.3 E	1 5 58.7	4 23.9
South Sea Castle - -	50 46 42 5	0 6 34.3 E	1 5 1 7	4 20.1
Porchester Church - -	50 50 12.7	0 5 6.9 E	1 6 29.1	4 25.9
Porchester Castle - -	50 50 18.6	0 5 0.5 E	1 6 35.5	4 26.3
Fareham Church - -	50 51 19.8	0 1 25.3 E	1 10 10.7	4 40.7
Hamble Saltern - -	50 51 0.9	0 6 39.2 W	1 18 15.2	5 13
Hamble Church - -	50 51 30.3	0 7 8.6 W	1 18 44.6	5 15
Calshot Castle - - -	50 43 12.7	0 6 29.6 W	1 18 5.6	5 12.4
Luttrell's Folly - -	50 48 22.5	0 7 31.5 W	1 19 7.5	5 16.5
Fawley Church - -	50 49 47.7	0 9 8.4 W	1 20 44.4	5 22.9
Hurst Castle - -	50 42 23.4	0 21 9.5 W	1 32 45.5	6 11
Hurst Light House - -	50 42 23 4	0 21 14 W	1 32 50	6 11.3
Ashey Down Sea Mark - -	50 41 6.8	0 0 38.2 E	1 10 57.8	4 43.8
East Cowes Sea Mark - -	50 45 37.5	0 4 39.2 W	1 16 15.2	5 5
West Cowes Fort - -	50 46 18.2	0 5 41.1 W	1 17 17.1	5 9.1
St. Catherine's Light House -	50 35 33.1	0 6 14.7 W	1 17 50.7	5 11.3
Needles Light House - -	50 39 53.2	0 22 19.2 W	1 33 55.2	6 15.7
Milford Church - -	50 43 41.7	0 23 23.9 W	1 34 59.9	6 20
Milton Church - -	50 44 55.2	0 27 52.4 W	1 39 28.4	6 37.9
Hordle Church - -	50 43 41.2	0 24 46.5 W	1 36 22.5	6 25.5
Lord Bute's House - -	50 44 14.5	0 30 33.7 W	1 42 9.7	6 48.6
Christchurch Head - -	50 42 57.3	0 33 34.5 W	1 45 10.5	7 0.7
Christchurch Tower - -	50 43 56.8	0 34 27.4 W	1 46 3.4	7 4.2
Ramsden Hill - -	50 46 7.5	0 36 32 W	1 48 8	7 12.5
Castle, Branksea Island - -	50 41 19.5	0 45 25.5 W	1 57 1.5	7 48.1
Poole Church - -	50 42 50	0 47 18.6 W	1 58 54.6	7 55.6
Flag-staff, Mr. Pitt's Factory -	50 36 46.5	0 51 31.9 W	2 3 7.9	8 12.5
Creech Barrow - -	50 38 9.8	0 54 38.9 W	2 6 14.9	8 25
Barrow, Swyre Head - -	50 36 32.4	0 53 34.8 W	2 5 10.8	8 20.7
Boat House - -	50 37 37.9	0 11 4 9 W	1 22 40.9	5 30.7
Wyke Church - -	50 35 57.5	1 16 34.2 W	2 28 10.2	9 52.7
Brixton Church - -	50 38 37.6	0 11 49.2 W	1 23 25 2	5 33.7
Horse-shoe Summer House -	50 44 34.2	0 6 57.7 W	1 18 33.7	5 14.2
Sir R. Worseley's Obelisk -	50 36 59.5	0 2 59.4 W	1 14 35.4	4 58.3
Ower Rocks - -	50 39 57.3	0 31 36.5 E	0 39 59.5	2 40

144. *Latitudes and Longitudes of those Places remote from the Sea Coast, which have been referred to the Meridian of Greenwich.*

Names of objects.	Latitude.	Longitude from Greenwich. In degrees.	Longitude from Greenwich. In time.
	° ′ ″	° ′ ″	m. s.
East Grinsted Church	51 7 27.9	0 0 16.2 E	0 1.1
Fairden Tower	51 9 21.3	0 0 53.9 E	0 3.6
Tatesfield Church	51 17 12.6	0 1 56.4 E	0 7.7
Evelyn's Obelisk, Felbridge Park	51 8 28.9	0 2 40 9 W	8 10.7
West Hoathly Church	54 4 35.4	0 3 13 W	0 12.9
Plumpton Church	50 54 19.1	0 4 12.1 W	0 16.8
Lindfield Church	51 0 52	0 4 38 W	0 18.5
Wyvelsfield Church	50 58 16	0 5 36.3 W	0 22.4
Little Horsted Church	50 56 44.1	0 5 35 E	0 22.3
Ditchling Church	50 55 17.8	0 6 49.5 W	0 27.3
Keymer Church	50 55 13.6	0 7 35.9 W	0 30.4
Cuckfield Church	51 0 18.3	0 8 29.8 W	0 34
Waldron Church	51 0 9.8	0 10 42.5 E	0 42.8
Crowborough Chapel	51 3 20.1	0 9 56.8 E	0 39.7
Hurstpierpoint Church	50 56 2.5	0 10 42.1 W	0 42.8
Chittingly Church	50 54 23.2	0 11 47 E	0 47.1
Bolney Church	50 59 23.9	0 12 5 W	0 48.3
Slaugham Church	51 2 18.7	0 12 21.4 W	0 49.4
Rotherfield Church	51 2 46.3	0 13 8.8 E	0 52.6
Charlwood Church	51 9 21.5	0 13 30.1 W	0 54
Mayfield Church	51 1 15.3	0 15 40 E	0 2.7
Homehurst Church	50 59 51	0 23 25.5 E	1 33.7
Bestbeech Windmill	5 3 34.8	0 18 30.7 E	1 14
Blackheath Windmill (near Heathfield)	50 57 50.9	0 19 0 E	1 16
Horsham Church	51 3 36	0 19 42.7 W	1 18.9
Hurstmonceux Church	50 51 34.6	0 19 41.7 E	1 18.8
West Grinsted Church	50 58 23.5	0 19 53.2 W	1 19.5
Dallington Church	50 56 50.4	0 21 31.8 E	1 26.1
Ninefield Church	50 53 7.1	0 25 21.6 E	1 41.4
Thakeham Church	50 56 41.8	0 25 7.1 W	1 40.5
Euhurst Church	51 9 11.7	0 26 16.6 W	1 45.1
Euhurst Windmill	51 10 21.7	0 27 26.9 W	1 49.9
Mountfield Church	50 56 50.4	0 29 6.7 E	1 56.4
St. Martha's Chapel	51 13 29	0 31 33.1 W	2 6.2
Norris's Obelisk	51 20 24.8	0 44 7 W	2 56.5
Farnham Castle	51 13 6.9	0 47 52 W	3 11.5
Nettlebed Station	51 34 45.1	0 58 57.1 W	3 55.8

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145. *Latitudes and Longitudes of those Places remote from the Sea Coast, which have been referred to the Meridian of Dunnose.*

Names of objects.	Latitude.	Longitude from Dunnose.	Longitude west of Greenwich. In degrees.	In time.
	° ′ ″	° ′ ″	° ′ ″	m. s.
Rusper Church - -	51 7 22.4	0 54 59.1 E	0 16 36.9	1 6.5
Billinghurst Church - -	51 1 20.6	0 44 43.9 E	0 26 52.1	1 47.5
Pulborough Church - -	50 57 25.5	0 41 22.4 E	0 30 13.6	2 0.9
Kirdford Church - - -	51 1 44.1	0 38 49.9 E	0 32 46.1	2 11.1
Petworth Windmill - -	50 59 22.5	0 36 40.7 E	0 34 53.3	2 19.6
Petworth Church - -	50 59 17	0 35 10.2 E	0 36 25.8	2 25.7
Earl of Egremont's Tower -	51 0 1.9	0 33 28.7 E	0 38 7.3	2 32.5
Wisborough Green Church -	51 1 20.1	0 41 41 E	0 29 55	1 59.7
Boxgrove Church - - -	50 51 36.7	0 29 10.1 E	0 42 25.9	2 49.7
Portfield Windmill - -	50 50 31.4	0 26 10.5 E	0 45 25.5	3 1.7
Rook's Hill Windmill - -	50 53 17.2	0 25 48.9 E	0 45 47.1	3 3.1
Halifax Tower - - -	50 52 47.5	0 18 0.4 E	0 53 35.6	3 34.4
Goodwood House - -	50 52 20.8	0 27 26.7 E	0 44 9.3	2 56.6
Bow Hill Station - -	50 53 40.4	0 22 3.3 E	0 49 32.7	3 18.2
Harting Windmill - -	50 57 32.7	0 19 38.2 E	0 51 57.8	3 27.8
Sir H. Fetherstonhaugh's Tower	50 57 30.3	0 18 52.3 E	0 52 43.7	3 30.9
Horndean Church - -	50 55 33.3	0 11 15.1 E	1 0 20.9	4 1.4
Southwick Church (*Hants*) -	50 52 27	0 5 11.7 E	1 6 24.3	4 25.6
Summer House, Kilminston Down	51 0 58.5	0 0 50.8 E	1 10 45.2	4 43
Carisbrook Castle - -	50 41 17.5	0 6 49.9 W	1 18 25.9	5 13.7
Bursledon Windmill - -	50 53 42.3	0 6 58.3 W	1 18 34.3	5 14.3
Thorness Station - -	50 44 1.1	0 10 7.5 W	1 21 43.5	5 26.9
Farley Monument - -	51 2 12.8	0 12 54.1 W	1 24 30.1	5 38
Southampton Spire - -	50 53 59.5	0 12 20.4 W	1 23 56.4	5 35.8
Stockbridge Hill Station -	51 6 55.3	0 15 32.2 W	1 27 8.2	5 48.5
Sir J. Doyley's House - -	50 46 33.3	0 19 3.4 W	1 30 39.4	6 2.6
Winterslow Church - -	51 5 29.7	0 28 27 W	1 40 3	6 40.2
Belvidere House - -	50 44 36.9	0 30 27.3 W	1 42 3.3	6 48.2
Everley Church - -	51 17 3.3	0 30 29.3 W	1 42 5.3	6 48.3
Ringwood Church - -	50 50 58	0 35 40 W	1 47 16	7 9.1
Summer House, Martincel's Hill	51 22 3.6	0 33 45 W	1 45 21	7 1.4
Summer House, Moyle's Court -	50 52 48.2	0 34 1.5 W	1 45 37.5	7 2.5
Amesbury Church - -	51 10 18.9	0 35 0.8 W	1 46 36.8	7 6.5
Salisbury Spire - -	51 3 48.9	0 35 24.2 W	1 47 0.2	7 8
Sopley Church - -	50 46 34.7	0 35 57.5 W	1 47 33.5	7 10.2
Stonehenge - -	51 10 44.3	0 37 31.8 W	1 49 7.8	7 16.5
Old Hartford Hut - -	51 9 1.8	0 39 32.1 W	1 51 8.1	7 24.5
S. Windmill } on Salisbury Plain	51 11 33	0 42 7.2 W	1 53 43.2	7 34.9
N. Windmill } on Salisbury Plain	51 12 3.4	0 43 44.8 W	1 55 20.8	7 41.4
Horton Observatory - -	50 51 37.9	0 45 25.3 W	1 57 1.3	7 48.1
Mr. Trenchard's Tower -	50 46 40.5	0 54 0.5 W	2 5 36.5	8 22.4
Clay Hill, or Copt Heap -	51 12 12	1 1 49.8 W	2 13 25.8	8 53.7
Alfred's Tower - -	51 6 54.4	1 9 45.5 W	2 21 21.5	9 25.4
Milbourn Obelisk - -	50 45 57.8	1 4 22.8 W	2 15 58.8	9 3.9
Fordington Church - -	50 42 52.2	1 13 35.5 W	2 25 11.5	9 40.7
Dorchester Church - -	50 42 57.7	1 14 4.1 W	2 25 40.1	9 42.7

Heights of the Stations; and Terrestrial Refractions.

146. *Elevations and Depressions.*

At Hanger Hill.

		′	″
The ground at St. Ann's Hill	*depr.*	4	36
at Banstead	*elev.*	10	39

At St. Ann's Hill.

		′	″	
The ground at Bagshot Heath	*elev.*	11	23	Instrument on the half scaffold: the axis of the telescope 20½ feet high.
at Banstead	*elev.*	10	2	
at Hanger Hill	*depr.*	6	13	
The top of the flagstaff near Hampton Poorhouse	*depr.*	12	54	

N.B. The flagstaff was about 41 feet high.

Near Hampton Poorhouse.

		′	″	
The ground at St. Ann's Hill	*elev.*	8	17	Instrument on the whole scaffold: the axis about 36½ feet high.

At Banstead.

		′	″	
The ground at Leith Hill	*elev.*	17	29	On the half scaffold: the axis 20½ feet high.
at Shooter's Hill	*depr.*	11	7	
at St. Ann's Hill	*depr.*	22	9	
at Hanger Hill	*depr.*	22	35	
The top of the flagstaff at Botley Hill - -	*elev.*	18	0	The staff about 29 feet high.

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At Leith Hill.

		′	″	
The top of the flagstaff at Banstead -	*depr.*	25	57	The staff about 27¼ feet high.
of the flagst. at Botley Hill	*depr.*	8	46	
The ground at Hind Head	*depr.*	8	28	
at Crowborough Beacon	*depr.*	13	48	
at Ditchling Beacon	*depr.*	12	34	
at Chanctonbury Ring	*depr.*	13	10	
The horizon of the sea through Shoreham Gap, on July 2d, 1792, at 10 in the forenoon. -	*depr.*	30	6	
The top of Severndroog Castle	*depr.*	22	9	

N. B. The axis of the telescope when at Shooter's Hill, was about 29½ feet lower than the top of the Castle.

At Shooter's Hill.

The ground at Leith Hill	*elev.*	2	35
at Banstead -	*elev.*	0	15

On Bagshot Heath.

The ground at Hind Head	*elev.*	10	37
at St. Ann's Hill	*depr.*	12	30

At Hind Head.

The ground at Leith Hill	*depr.*	2	59
at Chanctonbury Ring	*depr.*	11	11
at Rook's Hill -	*depr.*	14	51
at Butser Hill -	*depr.*	5	54
at Bagshot Heath	*depr.*	23	12
at Highclere -	*depr.*	10	42

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On Rook's Hill.

		′	″	
The ground at Hind Head	*elev.*	3	9	
at Dunnose	*depr.*	7	31	
at Butser Hill	*elev.*	7	23	
at Chanctonbury Ring	*depr.*	1	35	
at Bow Hill -	*depr.*	1	5	
at Portsdown -	*depr.*	16	22	
Horizon of the sea, in the Direction of Chichester spire, about noon on Sept. 2, 1792,	*depr.*	25	30	

At Butser Hill.

The ground at Highclere	*depr.*	9	29	
at Hind Head -	*depr.*	4	44	
at Motteston Down	*depr.*	15	27	
at Dunnose -	*depr.*	12	30	
Top of flagstaff at Rook's Hill	*depr.*	15	6	The staff 20 feet high.

At Chanctonbury Ring.

The ground at Rook's Hill	*depr.*	10	46	
at Hind Head	*depr.*	4	20	
at Leith Hill	*depr.*	1	13	
at Beachy Head	*depr.*	16	27	—On the half scaffold: the axis 20½ feet high.

At Dunnose.

The ground at Nine Barrow Down - -	*depr.*	15	37
at Dean Hill	*depr.*	17	24
at Rook's Hill	*depr.*	12	8
at Butser Hill	*depr.*	6	4

On Ditchling Beacon.

The ground at Leith Hill	*depr.*	4 36

On Fairlight Down.

The ground at Beachy Head	*depr.*	7 45
at Brightling Windmill	*depr.*	0 49

The ground at the Windmill is about 4 feet higher than the axis of the telescope when at Brightling.

On Brightling Down.

The ground at Fairlight Down	*depr.*	7 56
at Beachy Head -	*depr.*	8 44
at Crowborough Beacon	*elev.*	3 54

At Crowborough Beacon.

The ground at Leith Hill	*depr.*	4 8
at Brightling Windmill	*depr.*	12 21
at Botley Hill -	*depr.*	3 5

At Beachy Head.

The ground at Fairlight Down	*depr.*	5 17
at Brightling Windmill	*depr.*	1 48
at Chanctonbury Ring	*depr.*	5 6

At Dean Hill.

The ground at Highclere	*elev.*	0 46
at Beacon Hill	*elev.*	4 47
at Wingreen	*elev.*	5 5
at Dunnose	*depr.*	7 56

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At Beacon Hill.

The ground at Highclere	*depr.*	0°	15′
at Wingreen	*depr.*	0	34
at Dean Hill	*depr.*	13	13

At Highclere.

The ground at Hind Head	*depr.*	10	42
at Butser Hill	*depr.*	9	26
at Dean Hill	*depr.*	18	12
at Beacon Hill	*depr.*	13	15

On Nine Barrow Down.

The ground at Wingreen	*depr.*	1	20
at Dunnose	*depr.*	10	8
The sea in a south direction, about noon, April 11, 1794	*depr.*	24	16

At Wingreen.

The ground at Beacon Hill	*depr.*	15	30
at Nine Barrow Down	*depr.*	17	40
at Dean Hill -	*depr.*	20	19

N. B. The axis of the telescope was always about 5½ feet from the ground, unless the contrary is specified. And it is also to be noted, that 6″ must be subtracted from the elevations, and added to the depressions, on account of the error in the parallelism of the line of collimation of the telescope, and the rod attached to its side, upon which the level is hung.

147. *Height of the Station at Dunnose.*

With a view to obtain the heights of the stations nearly, from their elevations or depressions, we determined the height of that

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at Dunnose above low water, in May, 1793, by levelling down to the sea shore near Shanklin, a distance of about a mile. Instead of a levelling telescope, we made use of the transit instrument, which, on account of its very accurate spirit level, seems extremely well adapted for the purpose. Two circular wooden platforms were provided, broad enough for the feet of the transit stand; these platforms rested on pegs driven into the ground, and were always made horizontal at the time of levelling, by means of a mahogany spar, or straight-edge, furnished with a spirit level. The graduated rods, of course, were constantly set vertical on the lowest platform, while the transit stood on the other.

The ground is favourable enough down to Shanklin Chine: this is a large deep chasm, opening to the sea; but the descent is not so sudden on the western side, which is by far the steepest, and to which we levelled, but a person may get up or down with safety. We found its perpendicular height by means of several rods placed end ways against the sloping side, and supported in an horizontal position, and then letting fall a measuring tape from one rod to another: but this was the most troublesome and difficult part of the whole operation. The fall from the bottom of this chasm or opening, to the water's edge, was found in the usual manner.

The whole perpendicular descent thus determined, was 792 feet; which, we have no reason to suppose, is more than 2 or 3 feet wide of the truth. We finished at low water on May 10; and therefore the height of the station above low water at spring tides will, no doubt, be a very few feet more.

148. *Heights of Rook's Hill and Butser Hill.*

				′	″
At Dunnose	the ground at Rook's Hill	- -	*depr.*	12	14
	at Butser Hill	- -	*depr.*	6	10
At Rook's Hill	the ground at Dunnose	- -	*depr.*	7	37
	at Butser Hill	- -	*elev.*	7	17

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At Butser Hill { the ground at Dunnose - - *depr.* 12 36
top of the flagstaff at Rook's Hill - *depr.* 15 12

Dunnose and Rook's Hill	23 31	contained arcs nearly.
Dunnose and Butser Hill	23 3	
Butser Hill and Rook's Hill	9 59	

Hence, the mean refraction between Dunnose and Rook's Hill will be found 1′ 58″; between Dunnose and Butser Hill 2′ 16″; and between Butser Hill and Rook's Hill 47″; which are about $\frac{1}{12}$, $\frac{1}{10}$, $\frac{1}{13}$ of the contained arcs respectively, as in the table.

By the observations across the water, the ground at Rook's Hill would be 97 feet lower, and that at Butser Hill 132 feet higher, than Dunnose; the sum is 229 feet for the difference of heights of Butser Hill and Rook's Hill, obtained in this manner; but from the reciprocal observations, the ground at Rook's Hill is only 209 feet lower than at Butser Hill, which is less than the former difference by 20 feet; therefore, supposing each of the mean refractions to have produced an equal error in the heights, we have $792 - 97 + \frac{20}{3} = 702$ feet, for the height of Rook's Hill; and $792 + 132 - \frac{20}{3} = 917$ for that of Butser Hill. From those two determinations, the others in the following table have been obtained (the stations to the westward of Dunnose excepted) by taking a mean of the heights as derived from different routes. Those distinguished by an asterisk, were found by taking $\frac{1}{12}$ of the contained arcs for refraction.

149. *Table containing the Heights of the Stations.*

Stations.	Ground above low water. Feet.
Dunnose - - -	792
Rook's Hill - -	702

Stations.	Ground above low water. Feet.
Butser Hill - -	917
Hind Head - - -	923
Chanctonbury Ring -	814
Leith Hill - - -	993
Ditchling Beacon - -	858
Beachy Head - -	564
Fairlight Down - -	599
Brightling Down - -	646
Crowborough Beacon -	804
Botley Hill - - -	890*
Banstead - - -	576
Shooter's Hill - -	446
Hanger Hill - -	230
King's Arbour - -	118
Hampton Poorhouse -	86
St. Ann's Hill - -	240
Bagshot Heath - -	463
Dean Hill - - -	539
Beacon Hill - -	690
Old Sarum - -	266
Nine Barrow Down -	642
Highclere - - -	900
Wingreen - - -	941
Motteston Down - -	698*
Bow Hill - - -	702*
Portsdown Hill - -	447*

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150. *Table of the mean Terrestrial Refractions.*

Between		Mean Refraction.
Banstead and Shooter's Hill	-	$\frac{1}{7}$ of the contained arc.
St. Ann's Hill and Hampton Poorhouse		$\frac{1}{8}$
Brightling and Beachy Head	-	$\frac{1}{8}$
Beachy Head and Fairlight Down	-	$\frac{1}{10}$
Dunnose and Butser Hill	- -	$\frac{1}{10}$
Highclere and Butser Hill	-	$\frac{1}{10}$
Butser Hill and Hind Head	-	$\frac{1}{10}$
Beachy Head and Chanctonbury Ring		$\frac{1}{11}$
Highclere and Hind Head	-	$\frac{1}{11}$
Rook's Hill and Dunnose	- -	$\frac{1}{12}$
Leith Hill and Hind Head	-	$\frac{1}{12}$
Bagshot Heath and St. Ann's Hill	-	$\frac{1}{12}$
Dean Hill and Beacon Hill	-	$\frac{1}{12}$
St. Ann's Hill and Banstead	-	$\frac{1}{12}$
Dunnose and Nine Barrow Down	-	$\frac{1}{13}$
Leith Hill and Crowborough Beacon		$\frac{1}{13}$
Rook's Hill and Hind Head	-	$\frac{1}{13}$
Rook's Hill and Butser Hill	-	$\frac{1}{13}$
Dunnose and Dean Hill	- -	$\frac{1}{13}$
Dean Hill and Wingreen	- -	$\frac{1}{13}$
Brightling and Fairlight Down	-	$\frac{1}{13}$
Leith Hill and Chanctonbury Ring		$\frac{1}{13}$
Leith Hill and Shooter's Hill	-	$\frac{1}{13}$
Brightling and Crowborough Beacon		$\frac{1}{14}$
Hanger Hill and Banstead	-	$\frac{1}{14}$
Hanger Hill and St. Ann's Hill	-	$\frac{1}{14}$
Leith Hill and Banstead	- -	$\frac{1}{14}$
Beacon Hill and Wingreen	-	$\frac{1}{15}$

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Between	Mean Refraction.
Rook's Hill and Chanctonbury Ring	$\frac{1}{11}$ of the contained arc.
Nine Barrow Down and Wingreen	$\frac{1}{13}$
Leith Hill and Ditchling Beacon -	$\frac{1}{13}$
Mean of all the above, nearly -	$\frac{1}{12}$
Leith Hill and the Horizon -	$\frac{1}{10}$
Rook's Hill and the Horizon -	$\frac{1}{10}$
Nine Barrow Down and the Horizon	$\frac{1}{10}$

Remarks.

151. The height of the ground at the station on St. Ann's Hill, (149.) is 240 feet; but in the table, p. 180, it is 321 feet: this very great disagreement, however, principally arises from the variableness in the terrestrial refraction. At Hampton Poorhouse, *when the instrument was at the same height above the ground*, the difference in the elevations of the ground at St. Ann's Hill appears to have been no less than 9′ 28″, (p. 181). General Roy took $\frac{1}{10}$ of the contained arc for the effect of refraction, and considered the height of St. Ann's Hill, when deduced from that of the station near Hampton Poorhouse, as more accurate than could be obtained by way of the station at the Hundred Acres. But, previous to the Survey in 1787, he found by the barometer, that the station on St. Ann's Hill was 200 feet higher than the Thames at Shepperton; and he added 33 feet for the descent to low water at the sea; the sum is 233 feet, agreeing nearly with our determination.

We take the height of Botley Hill (890 feet) a mean of 900,885,885, which the observations at Leith Hill, Banstead, and Crowborough Beacon respectively produce, by making use of $\frac{1}{12}$ of the contained arcs for refraction: this height of the ground exceeds that deduced from the table, p. 179 $(880 - 21 = 859)$ by 31 feet: but we are

not certain of its being nearer the truth: only it may be remarked, that between the several stations from High Nook to Botley Hill, in the same table, the mean refractions are very great.

From the reciprocal observations at Leith Hill, Banstead, and Shooter's Hill, the height of the last station is 446 feet, which is the same, in fact, as that obtained in the following manner. General Roy found by levelling, that the floor of the upper story of the Bull Inn at Shooter's Hill was 444 feet above the Gun Wharf at Woolwich; and he allowed 22 feet for the fall to low water at the sea; the sum is 466 feet. In 1794, we levelled from the Inn to the Station, and found the latter 21 feet lower than the floor, which taken from 466, there remains 445 feet for the Station's height.

Notwithstanding this consistency, and also that in the height of St. Ann's Hill, found by different methods, it is evident from the observations at Dunnose, Rook's Hill, and Butser Hill, that relative heights deduced from elevations, or depressions, cannot always be depended upon to less than about 10 feet, even supposing those heights are the means of two or three independent results, except, perhaps, reciprocal observations were made exactly at the same time. The very great difference in the observed elevations of St. Ann's Hill, proves that no dependance can be placed on single observations. But that was not the only instance; for, at the station on Rook's Hill, we found the depression of the ground at Chanctonbury Ring, vary from 1′ 41″ to 2′ 30″. The observations, however, on which the tables are founded, were made in close cloudy days, or toward the evenings, when the tremulous motion in the air is commonly the least.

It has been conjectured, that the variations in terrestrial refraction, depend on the changes in the atmosphere indicated by the barometer and thermometer: this, however, cannot be the case when the rays of light pass near the earth's surface for any considerable distance. M. De la Lande, in his Astronomy (Art. *Terrest.*

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Ref.), remarks, that the mountains in Corsica are sometimes seen from the coasts of Genoa and Provence, but at other hours on the same days, they totally disappear, or are lost as it were in the sea. And the late General Roy frequently mentioned an instance of extraordinary refraction, which himself and Colonel Calderwood observed on Hounslow Heath, when they were tracing out the base. Their levelling telescope at King's Arbour was directed towards Hampton Poorhouse, where a flagstaff was erected at the end of the base; this for a long time they endeavoured in vain to discover, till at last, very unexpectedly, it suddenly started up into view, and so high it seemed to be lifted, that the surface of the ground where it stood became visible. This will appear the more extraordinary, when it is considered, that a right line drawn from the eye at King's Arbour to the other end of the base, would pass 8 or 9 feet below the surface of the intermediate ground near the Duke of St. Alban's Park. The following is still more singular. "I ob-" served," says Mr. Dalby, "what seemed to me a very uncom-" mon effect of terrestrial refraction, in April, 1793, as I went from "Freshwater Gate, in the Isle of Wight, towards the Needles. "Soon after you leave Freshwater Gate, you get on a straight and "easy ascent, which extends 2 or 3 miles; a mile, or perhaps a "mile and an half beyond this to the westward, is a rising ground, "or hill; and it is to be remarked, that its top and the aforesaid "straight ascent, are nearly in the same plane: now in walking "towards this hill, I observed that its top (the only part visible) "seemed to dance up and down in a very extraordinary manner; "which unusual appearance, however, evidently arose from unequal "refraction, and the up-and-down motion in walking; but when "the eye was brought to about 2 feet from the ground, the top of "the hill appeared totally detached, or lifted up from the lower "part, for the sky was seen under it. This phænomenon I re-" peatedly observed. There was much dew, and the sun rather

" warm for the season, consequently a great evaporation took place " at that time." Here, and also on Hounslow Heath, the rays of light passed near the earth's surface a great way before they arrived at the eye; and it is more than probable, that moist vapours were the principal cause of the very unusual refractions: the truth of which conjecture seems to be verified by the following circumstance. In measuring the base on Hounslow Heath, we had driven into the ground, at the distance of 100 feet from each other, about 30 pickets, so that their heads appeared through the boning telescope to be in a right line: this was done in the afternoon. The following morning proved uncommonly dewy, and the sun shone bright; when having occasion to replace the telescope, we remarked that the heads of the pickets exhibited a curve, concave upwards, the farthermost pickets rising the highest; and we concluded they were not properly driven, till in the afternoon, when we found that the curve appearance was lost, and the ebullition in the air had subsided.

The new raised earth about the gun at King's Arbour, prevented a very accurate measurement of the height of the instrument above the point of commencement of the base; and therefore two opportunities only presented themselves for determining the actual terrestrial refraction; namely, at the ends of the base of verification. From the depression taken at Beacon Hill, the refraction was 38″; but the elevation of Beacon Hill, observed at the lower end, near Old Sarum, gives 50″. These deductions, perhaps, cannot be deemed very conclusive; because, as they depend on the difference in the vertical heights of the ends of the base, every 2 inches of error in that difference will produce an error of about 1″ in the computed refraction. We shall close this article with the *data* whence those refractions were obtained.

At Beacon Hill, the top of the flagstaff near Old Sarum was depressed 42′ 6″.

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At the other end of the base, near Old Sarum, the top of the flagstaff at Beacon Hill was elevated 38′ 42″.

The axis of the telescope at Beacon Hill was 15 inches above, and the top of the flagstaff 91 inches above the point where the mensuration began. Near Old Sarum it was 28 inches higher, and the top of that flagstaff 95 inches above where the base terminated. This end (109.) is 429.48 feet lower than the other. Lastly, the value of the base is 6′ of a degree very nearly.

N. B. In the plan of the triangles (Pl. XX.), the line from the station near the Four Mile-stone to Old Sarum, is drawn a little out of its true position, otherwise it would very nearly coincide with that which joins the former station and Dean Hill.

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AN

ACCOUNT

OF THE

TRIGONOMETRICAL SURVEY

CARRIED ON IN THE

YEARS 1795, AND 1796,

BY ORDER OF THE MARQUIS CORNWALLIS,

MASTER GENERAL OF THE ORDNANCE.

BY

COLONEL EDWARD WILLIAMS,

AND

CAPT. WILLIAM MUDGE,

OF THE ROYAL ARTILLERY;

AND

MR. ISAAC DALBY.

AN

ACCOUNT, &c

Particulars relating to the Operations of the Year 1795.

152. In an early part of this season, from the necessity which existed of completing the Map of Kent for the Board of Ordnance, by order of the Master General, we had conceived that our former intentions, of continuing the Survey towards the west, would for the present be relinquished: as it was not imagined that the telescope of the small circular instrument, then in the hands of Mr. Ramsden, could be applied, with good effect, in observing staffs erected on very distant stations.

From the obvious importance, however, of adhering to the first resolution, it was determined that a trial should be made of the excellence of this instrument, in the construction of which extraordinary pains had been taken, by operating with it in Kent, and using it for those purposes to which, if the object before spoken of had not been in view, the great theodolite would have been necessarily applied.

This smaller theodolite, therefore, as a substitute, was in May taken into Kent by Mr. Dalby, and Mr. Gardner chief draughtsman in the Tower; the former being acquainted with the stations in the series of 1787.

On a reference to the account of 1794, it will be seen, that a

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station was chosen near Lulworth, and observed both from Nine Barrow Down and Black Down. It was also intended to be observed from Bull Barrow; by which means, instead of the great triangle formed by the stations Black Down, Nine Barrow Down, and Bull Barrow, we should have had two smaller ones. This, however, it was now found could not be done, as a signal house had been erected near the station at Lulworth, subsequent to the operations in 1794, which prevented that spot from being afterwards seen at Bull Barrow: but no consequences very injurious can have arisen from the impracticability of making use of this station in the manner originally proposed, since the stations formerly chosen in Portland, with which that of Lulworth was also intended to connect, have not been visited with the instrument. The stations in that island were selected with a view of observing from them, and Charton Common, some point in the vicinity of Torbay, which might be a proper station in the series intended to be carried along the coast. Such a situation, however, could not be conveniently found, as the view of Devonshire from Charton Common is much intercepted by trees and other obstacles; and it would have been highly improper to shorten the side between Pilsden Hill and the coast, by choosing a station more remote from the latter than Charton Common.

As from an inspection of the plan of the triangles annexed to this account, a doubt may be entertained as to the propriety of carrying on so very extensive a series from the short side connecting the stations on Black Down and Mintern Hill; it must be observed that, admitting the necessity of adopting Bull Barrow for a station, those on Pilsden and Mintern Hills were naturally chosen; the first, because it connected with Dumpdon (a station that could not be dispensed with); and the second, because it was the point most remote from Black Down, being on the brow of the high land overlooking the general surface of Somersetshire.

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To connect with the station formerly chosen near Maiden Bradley, two others were selected whilst the party were at Bull Barrow; one on Ash Beacon near Sherborne, and the other on the Quantock Hills. Both these have very commanding views, and will hereafter easily unite with any stations which may be chosen to the northward.

From Bull Barrow, the instrument was successively taken to the following stations, before any other new ones were chosen, *viz.* Mintern, Pilsden, and Charton Common; and whilst the party were at the latter, nearly all the stations were selected in Devonshire. In the choice of these, much difficulty occurred, as the face of this county is particularly unfavourable for operations of this kind. Around Honiton and Chard, there are several small ranges of hills, nearly of an equal height, running in parallel directions. Near the former are three thus circumstanced; *viz.* Hembury Fort, Combe Raleigh, and Dumpdon. From the first and second of these, the station on Charton Common is not visible; and it is from the last only, that both Pilsden and the Quantock Hills can be seen. This station, however, has a disadvantage: Combe Raleigh, which is to the west of it, takes off all view round Tiverton and Silferton; so that it became indispensibly necessary to select a spot on the northern extremity of Dartmoor, called Cawsand Beacon.

To those who are acquainted with the interior of Dartmoor, it will be unnecessary to assign the reason for not having chosen any station towards its centre. It may be sufficient to observe, that two spots were found on its circumference, which render the want of it trifling in its consequences.

Independent of the stations to which, as we have before observed, the instrument was taken this year, the following were visited, *viz.* Dumpdon, Little Haldon, Furland, and Butterton. From the latter, the party returned to London in the month of October.

153. *Angles taken in the Year* 1795.

At Bull Barrow.

Between	°	′	″	Mean. ″
Mintern Hill and Black Down	46	54	33	
			34.75	34
			34	
Black Down and Nine Barrow Down	84	31	22.25	23.25
			24	
Nine Barrow Down and Wingreen	93	33	0.5	0.25
		32	59.75	

At Mintern Hill.

	°	′	″	Mean.
Bull Barrow and Black Down	101	39	30	30.5
			31.25	
Black Down and Pilsden	68	30	45.75	46.5
			47	

On Charton Common.

	°	′	″	Mean.
Little Haldon and Dumpdon	68	12	49.75	
			51.25	51.25
			52.75	
Dumpdon and Pilsden	93	54	36.25	
			37.5	37.25
			38	
Pilsden and Black Down	47	39	17.5	18.5
			19.25	

On Pilsden Hill.

	°	′	″	Mean.
Mintern and Black Down	44	37	51.5	
			52.5	
			53	53.25
			54.25	
			55.5	
Black Down and Charton Common	105	5	27.75	
			26	26
			26	

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	°	′	″	Mean. ″
Between				
Charton Common and Dumpdon -	47	32	0.25	1.25
			1.25	
			2.5	

At Dumpdon.

	°	′	″	Mean. ″
Charton Common and Little Haldon	86	39	7	8.25
			7.25	
			8.5	
			8.75	
			9.25	
Little Haldon and Cawsand Beacon	35	7	6.5	7.25
			6.75	
			8.25	
Pilsden and Charton Common -	38	33	22	22.75
			22.25	
			22.25	
			23	
			23.5	
			23.5	

At Little Haldon.

	°	′	″	Mean. ″
Furland and Rippin Tor - -	84	58	42	42.5
			43	
Rippin Tor and Cawsand Beacon -	29	30	9.25	10.5
			11	
			11	
Dumpdon and Charton Common -	25	8	0.75	1.25
			2	
Dumpdon and Furland -	143	52	32.75	33.25
			33	
			34	

At Furland.

	°	′	″	Mean. ″
The Bolt Head and Butterton -	53	15	34.25	35
			35.75	

Between	°	′	″	Mean. ″
Butterton and Rippin Tor -	43	38	4 5.25	4.5
Rippin Tor and Little Haldon -	39	24	36.75 37.75	37.25

At Butterton.

Rippin Tor and Furland - -	74	21	56 56.5 57.25 58 58.5	57.25
Furland and the Bolt Head -	63	47	50.75 50.75	50.75
The Bolt Head and Kit Hill -	127	37	36.5 36.75	36.5
Maker Heights and Kit Hill -	42	11	38.75 38.75	38.75
Maker Heights and Carraton Hill -	35	30	28 28.75 29.75	28.75

Particulars relating to the Operations of the Year 1796.

154. By referring to Art. 109, it will be perceived that stones were sunk in the ground at the extremities of the base of verification on Salisbury Plain. To render these points permanent, two iron cannon (selected from among the unserviceable ordnance in Woolwich Warren) were, towards the end of February, sent to Salisbury, and in the beginning of March inserted at the ends of the base. The same methods were adopted for the purpose of fixing these cannon in their proper positions, as those made use of when similar *termini* were sunk in the ground on Hounslow Heath. This operation having been completed on the 10th of March, the

instrument was shortly after carried to Kit Hill, in Cornwall; a station, like that on Bindown, chosen rather for the purpose of a secondary, than a principal place of observation.

It would be tedious, and perhaps unnecessary, to enumerate the names of all the stations selected this year, as many of them do not form any part of the series now given to the public. We shall, therefore, confine ourselves to such remarks on the subject as may serve to abridge this article.

We have before stated, that a station was chosen on Cawsand Beacon, the northern extremity of Dartmoor, for the purpose of connecting with Dumpdon. It should have been observed, that to the westward of the former eminence, and near it, there is a hill considerably higher, which, in point of situation, has many advantages, but which cannot be made use of on account of the ruggedness of its surface, which seems to render the carrying of the instrument to its top almost impossible. From this circumstance, and similar impediments, which the high lands remote from the circumference of Dartmoor offer to our operations, it results, that the body of this moor cannot have any great triangles carried over it: such stations were therefore selected this year as may serve, in conjunction with others, to include this tract of country in a polygon of a small number of sides.

To make observations for the purpose of hereafter determining the longitude and latitude of the Lizard, was a principal object in this year's operations; and as this headland seems to offer itself as very convenient for a station, it will be right to assign our reasons for not having chosen one upon it.

As no other spot but Hensbarrow Beacon could be found in that part of Cornwall proper for a station, it became necessary to fix on the Deadman, or Dodman, for another point in the series. From this place no part of the land within four miles of the Lizard can be seen, as the high ground about Black Head, which is to the

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eastward of the latter, is nearly in a line between them, and is also much higher than both. It will be perceived, however, that no evil can result from the want of such a station, as the light-houses and the naval-signal-staff at the Lizard, have been intersected from several stations. The precise spot on which Mr. Bradley made his observations in the year 1769, for ascertaining the longitude and latitude of this headland, was pointed out by the person having the care of the light-houses, who well remembered the common particulars relating to his operations: such measurements were made from the light-houses to this spot, as may enable us, at a future period, to compare the results from the *data* afforded by the trigonometrical operation, with those deduced from the astronomical observations made by the above gentleman. It may be also mentioned, that angles were at the same time taken at the western light-house and signal-staff, for the purpose of finding the situation of the Lizard Point.

We are now to speak of the most important business performed this year; that of making observations to determine the distance of the Scilly Isles from the Land's End.

To do this as accurately as possible, it became necessary to find stations affording the longest *base*. The hill near *Rosemergy*, called the *Watch*, and the station near St. Buryan, are certainly the most advantageous places, because all the islands can be seen from both; but we could not avail ourselves of the former, as difficulties almost insuperable would have attended an attempt to get the instrument upon it. Another station was therefore selected on Karnminnis, near *St. Ives*; a spot as well situated as the place spoken of, provided all the islands could be seen: this, however, does not prove to be the case, *St. Martin's Day-Mark* being the only object in the Scilly Islands visible from Karnminnis.

From the stations near the Land's End (Sennen and Pertinney), as well as that above mentioned (St. Buryan), St. Agnes' Light-

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house, and two objects in St. Mary's, were observed; and as the means by which all their distances are determined, except those of the Day-Mark, from the shortness of the bases (which were, however, the longest that could be found) are exceptionable, it will be right to mention, that while we were engaged in that part of the operation now spoken of, the air was so unusually clear, that we could sometimes, with the telescope of the great theodolite, discover the soldiers at exercise in St. Mary's Island.

Under this article, it will be convenient to state, that we have endeavoured to find some spot to the westward, on which a base might be measured. Had we been fortunate in this respect, it undoubtedly would be eminently advantageous: as those triangles, now extended to the Land's End, would, in that case, be verified in some part of the new series. In Devonshire and Cornwall, however, no place has been discovered by any means fit for the purpose; so that our communicating this work, under the circumstances attending it, is a matter of necessity.

In the present and former seasons, such stations were selected and observed, as were judged to be proper for the future use of the small instrument; and as we had experienced, in the early stage of this Survey, much delay and disappointment from the white lights not being always seen when fired on distant stations, we have since substituted lamps and staffs in their stead. The operations of the present year were continued till October, when the party returned to London.

155. *Angles taken in the Year* 1796.

At Kit Hill.

Between	° ′ ″	Mean. ″
Butterton and Maker Heights -	48 36 45 47.75	46.5

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Between	°	′	″	Mean. ″
Maker Heights and Bindown	53	21	13.75	
Carraton Hill and Bindown	50	45	31	
On Maker Heights.				
Lansallos and Carraton Hill	48	39	54.75 54.75	54.75
Carraton and Butterton	112	18	7.75 9.75	8.75
Butterton and the Bolt Head	45	54	35.75 38.5	37
Bindown and Carraton Hill	28	22	50.75	
Bindown and Kit Hill	51	29	20.5 24.5	22.5
Kit Hill and Butterton	89	11	33.25 36	34.75
At the Bolt Head.				
Maker Heights and Butterton	48	39	24.5 24.75	24.75
Butterton and Furland	62	56	36.5	
At Rippin Tor.				
Cawsand Beacon and Little Haldon	124	59	12.75 13.5	13
Little Haldon and Furland	55	36	39 41.75	40.5
Furland and Butterton	61	59	59.25 59.5	59.5
On Cawsand Beacon.				
Dumpdon and Little Haldon	43	14	20 22.5	21.25
Little Haldon and Rippin Tor	25	30	39.5 40.25	39.75

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On Carraton Hill.

Between	°	′	″	Mean.
Maker Heights and Lansallos -	67	12	20.25	21.75
			23.5	
Lansallos and Bodmin Down -	56	21	16.75	17
			17	
Lansallos and Hensbarrow Beacon -	37	28	57.75	58
			58	
Butterton and Maker Heights -	32	11	22.5	23
			23.5	
Kit Hill and Bindown - -	91	45	22.5	
Maker Heights and Bindown -	38	58	38.5	

On Bindown.

Lansallos and Carraton Hill -	119	9	36.25	
Carraton Hill and Kit Hill - -	37	29	5.75	
Kit Hill and Maker Heights -	75	9	24.5	

At Lansallos, or Polvinton Farm.

Deadman and Hensbarrow Beacon -	52	34	2	3
			2.5	
			5	
Hensbarrow Beacon and Bodmin Down	45	1	10.75	11.75
			12.75	
Bodmin Down and Carraton Hill -	54	57	43.25	44
			44.75	
Carraton Hill and Bindown - -	32	36	43.25	
Carraton Hill and Maker Heights -	64	7	43.5	44.25
			43.75	
			45.75	

On Bodmin Down.

Carraton Hill and Lansallos - -	68	40	57.75	59
		41	0.75	
		40	58.5	

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Between	°	′	″	Mean.
Lansallos and Hensbarrow Beacon -	67	59	27.5 28	27.75
On Hensbarrow Beacon.				
Carraton Hill and Lansallos -	42	32	8.5	
Bodmin Down and Lansallos -	66	59	21.75 25	23.25
Lansallos and Deadman - -	71	13	35 35.25 35.5	35.25
Deadman and St. Agnes' Beacon -	77	20	28.5 28.75 31.5	29.5
On St. Agnes' Beacon.				
Hensbarrow Beacon and Deadman -	34	31	17 21 23	20.25
Deadman and Karnbonellis - -	75	51	53 53.75	53.25
Karnbonellis and Karnminnis -	57	46	31 31.5	31.25
On Karnminnis.				
St. Agnes' Beacon and Karnbonellis	32	30	0.25 0.25	0.25
Kárnbonellis and St. Buryan -	111	53	15.5 16.5	16
St. Buryan and Pertinney - -	13	48	16.75 17 20.75	18
At St. Buryan.				
Karnminnis and Karnbonellis -	41	43	45.25 45.5 45	45.25

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Between	°	′	″	Mean.
Pertinney and Karnminnis - -	52	31	27.5 27.5	27.5
Sennen and Pertinney - - -	75	36	11 11.75 12	11.5

At Sennen.

Pertinney and St. Buryan - -	36	39	18.5 19.25	18.75

On Pertinney.

Karnminnis and St. Buryan - -	113	40	15.25 16	15.5
St. Buryan and Sennen - -	67	44	30.5 31.25	31

At Karnbonellis.

St. Buryan and Karnminnis - -	26	22	59.25 59.5	59.25
Karnminnis and St. Agnes' Beacon -	89	43	27.25 28.75 31.25	29
St. Agnes' Beacon and the Deadman	78	16	39.75 40.5 43	41

On the Deadman, or Dodman Point.

Karnbonellis and St. Agnes' Beacon -	25	51	24.5 24.75	24.75
St. Agnes' Beacon and Hensbarrow Beacon	68	8	12.5 13.75	13
Hensbarrow Beacon and Lansallos -	56	12	22.5 22.75	22.75

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156. *Situations of the Stations.*

Mintern or *Revel's Hill.* This station is in Dorsetshire, and situated on Revel's Hill, which is not far from Mintern. It is 17 feet N. E. from the corner of the hedge.

Pilsden. This station is also in Dorsetshire, and near Broadwindsor. The point is on the S. E. corner of the old parapet.

Charton Common. The station is in the field adjoining to, and also to the westward of the Common, and is about two miles from Lyme: it is 50 yards from the eastern hedge, and may be easily found, as Black Down is only visible from that spot, being seen between two trees.

Dumpdon; about three miles N. E. of Honiton. The station is 10 feet northward of the hedge of the plantation, and nearly on the highest part of the hill.

Little Haldon; near Teignmouth, in Devonshire. The station is 80 yards from the *Direction Post*, and in a line with it and the Obelisk on *Great Haldon.*

Cawsand Beacon; near South Zeal. The station is about 200 feet north of the Karn, or great heap of stones.

Rippin Tor. This station is also on Dartmoor, and about 5 miles from Ashburton. The point is mid-way between the two heaps of stones.

Furland; a field near the turnpike-gate between Brixen and Dartmouth. The station is near the stone, erected in the middle of the field.

Butterton. The station is 45 feet S. W. of the Karn on the hill called by this name, and about 1 mile from Ivy Bridge.

The Bolt Head. The station is on the spot called *White Soar*, above the Bolt; it is 95 feet in the line produced northward from

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the west side of the signal-house, and about 90 feet from the nearest corner of it.

Maker Heights. This spot is near Cawsand, and the station is 45 feet from the great flag-staff, in the line produced from Statten Battery passing by the side of the staff.

Kit Hill, near Callington. The station is on the S. W. bastion of a work similar to an Indian fortification.

Carraton Hill. This station is about 4 miles north of Liskeard; and the point 150 yards south of the highest Karn on the top of the hill.

Bindown, near Looe. The station is about 50 yards eastward of the barrow on this hill.

Lansallos. The station is in a field belonging to *Polvinton Farm,* which is near that town. The point is 159 feet from the western bank, and $90\frac{1}{2}$ from the southern one.

On Bodmin Down. The station 120 yards south of the high road, and about a quarter of a mile east of the turnpike gate. The point is in the centre of a remarkable ring.

Hensbarrow Beacon, near St. Roach. The station is on the top of the barrow.

The Deadman, or *Dodman Head.* The station is about 40 feet south of the bank, and nearly 100 yards to the east of the entrance into the inclosure.

St. Agnes' Beacon. The station is on the southern brow of the beacon, and about 80 yards from the tower.

Karnbonellis. The station is 90 yards south of the northern Karn, or heap of stones. The hill called *Karnbonellis* is near *Porcillis.*

Pertinney. The station is in the middle of the ring on its top. This hill is about 2 miles eastward of *St. Just.*

Sennen. This station is in the north-west corner of a field belonging to Mr. Williams. The field may be easily found, as there

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is no other spot near the town of Sennen, from which the Long ship's Light-house, Pertinney, and St. Buryan, can be seen.

Karnminnis, near St. Ives. The station on the top of this hill, may be found from the following measurements:

	Feet	In.			
The station from 3 large moor-stones, south of the hedge.	8	8	from the south		stones.
	11	0	——	north	
	14	1	——	west	

St. Buryan. The station is in a field adjoining the town, and by the side of the *Penzance* road. It is $84\frac{1}{2}$ feet from the stile, and 48 feet from a large stone in the northern hedge. This stone is 81 feet from the stile; the Station, this stone, and Chapel Karnbury, being in a right line.

157. ***Calculation of the Sides of the great Triangles, carried on from the Termination of the former Series, along the Coasts of Dorsetshire, Devonshire, and Cornwall, to the Land's End. Pl. XXI.***

Distance from Wingreen to Nine Barrow Down, 130224.4 Feet (Triang. XXVI. Art. 117.)

No. of triangles.	Names of the stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
XLIII.	Wingreen -	54 29 36.5	−0.4			54 29 36	
	Bull Barrow -	93 33 0 25	−0 91			93 32 59	
	Nine Barrow Down	31 57 25.5	−0 4			31 57 25	
		180 0 2.25		1.72	+0.53		
	Bull Barrow from { Wingreen -					— — —	69058
	Nine Barrow Down					— — —	100213
XLIV.	Black Down -	56 30 18 75	−0 53			56 30 18 5	
	Nine Barrow Down	38 58 19 25	−0 89			38 58 19	
	Bull Barrow -	84 31 23 25	−0.57			84 31 22.5	
		180 0 1.25		1.99	−0.74		
	Black Down from { Nine Barrow Down					— — —	126782
	Bull Barrow -					— — —	80103.8

No. of triangles.	Names of the stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
XLV.	Mintern -	101 39 30.5	−0.36			101 39 30	
	Bull Barrow -	46 54 34	−0.09			46 54 33.5	
	Black Down -	31 25 57.5	−0.11			31 25 56.5	
		180 0 2		0.59	+1.41		
	Mintern from { Bull Barrow -					— — —	42653.4
	{ Black Down -					— — —	59730
XLVI.	Pilsden -	44 37 53.25	−0.29			44 37 53	
	Mintern Hill	68 30 46.5	−0.36			68 30 46	
	Black Down -	66 51 21.25	−0.36			66 51 21	
		180 0 1		1	−0.02		
	Pilsden from { Mintern Hill -					— — —	78177
	{ Black Down -					— — —	79110.7
XLVII.	Charton Common	47 39 18.5	−0.10			47 39 18.5	
	Black Down -	27 15 14*	−0.21			27 15 16	
	Pilsden - -	105 5 26	−0.60			105 5 25.5	
		179 59 58.5		0.88	−2.38		
	Charton Common from { Black Down -					— — —	103345
	{ Pilsden - -					— — —	49106.3
XLVIII.	Dumpdon -	38 33 22.75	−0.12			38 33 22.25	
	Pilsden - -	47 32 1.25	−0.14			47 32 1	
	Charton Common	93 54 37.25	−0.36			93 54 36.75	
		180 0 1.25		0.66	+0.59		
	Charton Common from { Dumpdon -					— — —	49016.3
	{ Pilsden - -					— — —	78459.3
XLIX.	Little Haldon -	25 8 1.25	−0.45			25 8 1	
	Charton Common	68 12 51.25	−0.48			68 12 51	
	Dumpdon -	86 39 8.5	−0.78			86 39 8	
		180 0 1		0.66	+0.34		
	Little Haldon from { Charton Common					— — —	136353
	{ Dumpdon -					— — —	126831
L.	Cawsand Beacon	43 14 21.25	−0.57			43 14 20	
	Dumpdon -	35 7 7.25	−0.64			35 7 7	
	Little Haldon -	101 38 33.75	−1.93			101 38 33	
		180 0 2.25		3.12	−0 87		
	Cawsand Beacon from { Dumpdon - -					— — —	181334
	{ Little Haldon -					— — —	106508

* This angle (104.) is considered to be nearly 2″ in defect, and has been augmented for calculation accordingly: it was observed under circumstances less favourable, than those which attended the observations made on Pilsden, and Charton Common.

No. of triangles.	Names of the stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
LI.	Rippin Tor -	124 59 13	−0.08			124 59 11.75	
	Cawsand Beacon	25 30 39.75	+0.01			25 30 38.75	
	Little Haldon -	29 30 10.5	+0.05			29 30 9.5	
		180 0 3.25		0.69	+2.56		
	Rippin Tor from Cawsand Beacon -					— — —	64020.5
	Rippin Tor from Little Haldon -					— — —	55988.7
LII.	Furland - -	39 24 37.25	−0.26			39 24 37	
	Little Haldon -	84 58 43	−0.44			84 58 42.75	
	Rippin Tor -	55 36 40.5	−0.25			55 36 40.25	
		180 0 0.75		0.96	−0.21		
	Furland from Little Haldon -					— — —	72776
	Furland from Rippin Tor - -					— — —	87851
LIII.	Furland - -	43 38 4.5	−0.32			43 38 4	
	Rippin Tor -	61 59 59.5	−0.38			61 59 59.25	
	Butterton - -	74 21 57.25	−0.44			74 21 56.75	
		180 0 1.25		1.15	+0 1		
	Butterton from Rippin Tor -					— — —	62951
	Butterton from Furland - -					— — —	80547.8
LIV.	Bolt Head -	62 56 36.5	−0 41			62 56 35.25	
	Furland - -	53 15 35	−0.38			53 15 34.75	
	Butterton -	63 47 50.75	−0 43			63 47 50	
		180 0 2.25		1.23	+1.02		
	Bolt Head from Furland - -					— — —	81152
	Bolt Head from Butterton - -					— — —	72479.8
LV.	Maker Heights -	45 54 37	−0 42			45 54 37 5	
	Bolt Head -	48 39 24.5	−0.33			48 39 24.5	
	Butterton -	85 25 58	−0.59			85 25 58	
		179 59 59 5		1.29	−1.79		
	Maker Heights from Bolt Head -					— — —	100591
	Maker Heights from Butterton - -					— — —	75768.8
LVI.	Maker Heights	112 18 8.75	−1.09			112 18 8	
	Butterton -	35 30 28.75	−0.17			35 30 29	
	Carraton Hill -	32 11 23	−0.10			32 11 23	
		180 0 0.5		1.36	−0.86		
	Carraton Hill from Butterton - -					— — —	131576
	Carraton Hill from Maker Heights -					— — —	82600.3

No. of triangles.	Names of the stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
LVII.	Lansallos -	64 7 44.25	−0.44			64 7 44	
	Maker Heights -	48 39 54.75	−0.36			48 39 54.5	
	Carraton Hill -	67 12 21.75	−0.43			67 12 21.5	
		180 0 0.75		1.24	−0.49		
	Lansallos from { Maker Heights -					— — —	84631.4
	Lansallos from { Carraton Hill -					— — —	68929.7

By the latter triangle we get the distanee from Lansallos to Carraton Hill 68929.7 feet; which being obtained from the least number of triangles, we shall make use of in the calculations of the sides farther to the westward. The same eonclusion, however, is nearly obtained by making the eomputations pass through the triangles connected with Kit Hill and the station on Bindown.

No. of triangles.	Names of the stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
LVIII.	Kit Hill -	48 36 46.75	−0.26			48 36 46.75	
	Butterton -	42 11 38.75	−0.20			42 11 38.75	
	Maker Heights	89 11 34.5	−0.75			89 11 34.5	
		180 0 0		1.21	−1.21		
	Kit Hill from { Butterton -					— — —	100969
	Kit Hill from { Maker Heights -					— — —	67822.3
LIX.	Bindown -	75 9 24.5	−0.28			75 9 24.25	
	Maker Heights -	51 29 22.5	−0.17			51 29 22.25	
	Kit Hill - -	53 21 13.75	−0.22			53 21 13.5	
		180 0 0.75		0.70	+0.05		
	Bindown from { Maker Heights -					— — —	56294.8
	Bindown from { Kit Hill - -					— — —	54902.7
LX.	Carraton Hill -	91 45 22.5				91 45 23	
	Kit Hill -	50 45 31				50 45 31	
	Bindown -	37 29 5.75				37 29 6	
		179 59 59.25		0.42	−1.17		
	Carraton Hill from { Kit Hill - -					— — —	33427
	Carraton Hill from { Bindown - .					— — —	42541.4
LXI.	Lansallos -	32 36 43.25				32 36 42.25	
	Bindown -	119 9 36.25				119 9 35.25	
	Carraton Hill -	28 13 43.25				28 13 42.5	
		180 0 2.75		0.33	+2.42	— — —	
	Lansallos from Bindown - -					— — —	37335.3

By the last triangle we get the distance from Lansallos to Carraton 68931 feet. We shall, however, as before observed, use the distance between those stations as derived from the LVII. triangle.

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No. of triangles.	Names of the stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
LXII.	Lansallos -	54 57 44	—0.26			54 57 44	
	Carraton Hill	56 21 17	—0.27			56 21 17	
	Bodmin Down	68 40 59	—0.30			68 40 59	
		180 0 0		0.82	—0.82		
	Bodmin Down from { Carraton Hill					— — —	60582.7
	Lansallos -					— — —	61597.1
LXIII.	Hensbarrow Beacon	66 59 23.25	—0.23			66 59 22.25	
	Bodmin Down	67 59 27.75	—0.21			67 59 26.75	
	Lansallos -	45 1 11.75	—0.19			45 1 11	
		180 0 2.75		0.63	+ 2.12		
	Hensbarrow Beacon from Bodmin Down					— — —	47337.2

By this last triangle, the distance from Hensbarrow Beacon to Lansallos is found to be 62044.8 feet, and by the following triangle

No. of triangles.	Names of the stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
LXIV.	Hensbarrow Beacon	42 32 8.5	—0.20			42 32 8	
	Carraton Hill	37 28 58	—0.18			37 28 57.5	
	Lansallos -	99 58 55.75	—0.59			99 58 54.5	
		180 0 2.25		0.99	+ 1.26		
	Hensbarrow Beacon from Carraton Hill					— — —	100416
	We get 62044.7 feet for the same distance.						
LXV.	Deadman -	56 12 22.75	—0.25			56 12 22.5	
	Lansallos - -	52 34 3	—0.24			52 34 2.5	
	Hensbarrow Beacon	71 13 35.25	—0.35			71 13 35	
		180 0 1		0.82	+ 0.18		
	Deadman from { Lansallos -					— — —	70686.8
	Hensbarrow Beacon					— — —	59284.2
LXVI.	St. Agnes' Beacon	34 31 20.25	—0.31			34 31 19.25	
	Hensbarrow Beacon	77 20 29.5	—0.54			77 20 28.75	
	Deadman -	68 8 13	—0.63			68 8 12	
		180 0 2.75		1.32	+ 1 43		
	- St. Agnes' Beacon from { Hensbarrow Beacon					— — —	97084.8
	Deadman -					— — —	102066
LXVII.	St. Agnes' Beacon	75 51 53.75	—0 40			75 51 53.5	
	Deadman -	25 51 24.75	—0.30			25 51 25 25	
	Karnbonellls -	78 16 41	—0.40			78 16 41.25	
		179 59 59 5		1.06	—1.56		
	Karnbonellis from { Deadman -					— — —	101084
	St. Agnes' Beacon					— — —	45461.9

No. of triangles.	Names of the stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
LXVIII.	Karnminnis -	32 30 0.25	—0.22			32 30 0.25	
	St. Agnes' Beacon	57 46 31.25	—0.35			57 46 31	
	Karnbonellis -	89 43 29	—0.53			89 43 28.75	
		180 0 0.5		0.77	—0.27		
	Karnminnis from { St. Agnes' Beacon					— — —	84610.6
	Karnbonellis -					— — —	71578.3
LXIX.	St. Buryan -	41 43 45.5	—0.03			41 43 45.25	
	Karnbonellis -	26 22 59.25	—0.09			26 22 59.25	
	Karnminnis -	111 53 16	—0.65			111 53 15.5	
		180 0 0.75		0.75	0.0		
	St. Buryan from { Karnbonellis -					— — —	99786
	Karnminnis -					— — —	47786.7
LXX.	Pertinney -	113 40 15.5				113 40 15	
	Karnminnis -	13 48 18				13 48 18	
	St. Buryan -	52 31 27.5				52 31 27	
		180 0 1		0.16	+0.84		
	Pertinney from { Karnminnis -					— — —	41407.7
	St. Buryan -					— — —	12450.2
LXXI.	Sennen -	36 39 18.75				36 39 18.25	
	St. Buryan -	75 36 11.5				75 36 11	
	Pertinney -	67 44 31				67 44 30.75	
		180 0 1.25		0.08	+1.17		
	Sennen from { St. Buryan -					— — —	19300.8
	Pertinney -					— — —	20199.9

Terrestrial Refractions, and Heights of the Stations.

158. *Elevations and Depressions.*

At Wingreen.

		′	″
The ground at Bull Barrow - -	*depressed*	6	3

At Nine Barrow Down.

The ground at Black Down - -	*depr.*	3	29
at Bull Barrow - - -	*elevated*	1	25

At Black Down.

The ground at Nine Barrow Down	-	*depr.*	13′ 26″
at Charton Common	- -	*depr.*	15 11
at Mintern Hill	- - -		0 0
at Bull Barrow	- - - -	*depr.*	1 16
at Pilsden	- - -	*depr.*	0 50

At Pilsden Hill.

The ground at Black Down	- - -	*depr.*	11 0
at Charton Common	- -	*depr.*	28 39
The horizon of the sea on the 6th of June, at 6 P. M. in a S. E. direction, nearly,		*depr.*	29 23

At Bull Barrow.

The ground at Wingreen	- -	*depr.*	4 53
at Mintern	- - -	*depr.*	6 5
at Black Down	- -	*depr.*	10 39

On Charton Common.

The ground at Black Down	- -		0 0
at Pilsden	- - - -	*elev.*	20 37
at Haldon	- - -	*depr.*	3 33

At Dumpdon.

The ground at Pilsden	- - -	*depr.*	3 45
at Charton	- - - -	*depr.*	22 12
The bottom of the Karn, or heap of stones, (nearly on a level with the axis of the telescope) on Cawsand Beacon	- - -	*elev.*	4 42

At Haldon.

The ground at Charton	- - -	*depr.*	15′ 59″
at Cawsand Beacon	- -	*elev.*	24 3
at Rippin Tor	- -	*elev.*	40 49
at Furland	- - -	*depr.*	16 6
The horizon of the sea on the 27th of July, at 6 P. M. in a S. W. direction, nearly,		*depr.*	27 24

On Cawsand Beacon.

The ground at Rippin Tor	- -	*depr.*	17 42
at Haldon	- - -	*depr.*	38 57
The lamp at Dumpdon	- - -	*depr.*	29 36

N. B. The lamp was about $5\frac{1}{2}$ feet from the ground.

On Rippin Tor.

The ground at Butterton	- - -	*depr.*	23 38
at Cawsand Beacon	- - -	*elev.*	8 3
at Haldon	- - -	*depr.*	49 31

At Furland.

The ground at Haldon	- - -	*elev.*	5 27
at Butterton	- - -	*elev.*	20 15

At Butterton.

The ground at Kit Hill	- - -	*depr.*	10 49
at Carraton	- - -	*depr.*	9 0
at Maker Heights	- -	*depr.*	41 48
at the Bolt Head	- - -	*depr.*	41 48
at Furland	- - -	*depr.*	32 18
at Rippin Tor	- - -	*elev.*	13 54

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On Maker Heights.

The ground at Lansallos	- - -	*depr.*	1 27
at Bindown	- - - -	*elev.*	11 32
at Carraton Hill	- - -	*elev.*	27 36
at Kit Hill	- - - -	*elev.*	29 45
at Butterton	- - -	*elev.*	30 35
at the Bolt Head	- - -	*depr.*	5 47

At the Bolt Head.

The ground at Maker	- - - -	*depr.*	7 42
at Butterton	- - -	*elev.*	31 6

At Kit Hill.

The ground at Butterton	- - - -	*depr.*	1 42
at Maker Heights	- - -	*depr.*	37 38
at Bindown	- - -	*depr.*	31 0
at Carraton Hill	- - -	*elev.*	9 38

On Carraton Hill.

The ground at Lansallos	- - - -	*depr.*	41 18
at Hensbarrow	- -	*depr.*	13 27
at Maker Heights	- -	*depr.*	39 30
at Bindown	- - - -	*depr.*	47 48
at Butterton	- - -	*depr.*	9 48
at Kit Hill	- - -	*depr.*	15 19

On Bindown.

The ground at Maker Heights	- -	*depr.*	19 41
at Carraton Hill	- - -	*elev.*	41 20

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The ground at Lansallos	- - - -	*depr.*	16′ 24″
at Hensbarrow	- -	*elev.*	7 10
at Kit Hill	- - -	*elev.*	22 51

At Lansallos.

The ground at Carraton Hill	- - -	*elev.*	30 18
at Bindown	- - -	*elev.*	10 46
at Kit Hill	- - - -	*elev.*	15 27
at Bodmin Down	- -	*elev.*	2 56
at Hensbarrow	- - -	*elev.*	23 57
at the Deadman	- -	*depr.*	11 39
at Maker Heights	- -	*depr.*	10 30

On Bodmin Down.

The ground at Hensbarrow	- -	*elev.*	24 3
at Lansallos	- - -	*depr.*	12 9

On Hensbarrow Beacon.

The ground at Carraton	- - - -	*depr.*	0 36
at Lansallos	- - -	*depr.*	33 23
at the Deadman	- -	*depr.*	42 8
at St. Agnes' Beacon	- -	*depr.*	21 53
at Bodmin Down	- - -	*depr.*	31 21

At the Deadman.

The ground at Karnbonellis	- - -	*elev.*	7 51
at St. Agnes' Beacon	- -	*elev.*	0 19
at Hensbarrow	- - -	*elev.*	33 30
at Lansallos	- - - -	*elev.*	1 30

At St. Agnes' Beacon.

		′	″
The ground at Karnminnis - - -	*elev.*	2	11
at Karnbonellis - - -	*elev.*	12	45
at Hensbarrow - -	*elev.*	8	8
at the Deadman - -	*depr.*	14	15

On Karnbonellis.

The ground at St. Agnes' Beacon - -	*depr.*	19	51
at Karnminnis - -	*depr.*	5	51
at St. Buryan - - - -	*depr.*	20	56
at the Deadman - - -	*depr.*	22	18

On Karnminnis.

The ground at St. Buryan - - -	*depr.*	32	9
at Karnbonellis - -	*depr.*	4	30
at St. Agnes' Beacon - -	*depr.*	14	12
at Pertinney Hill - -	*depr.*	9	14

At St. Buryan.

The ground at Karnminnis - -	*elev.*	24	32
at Karnbonellis - - -	*elev.*	6	50

N. B. The axis of the telescope was about $5\frac{1}{2}$ feet from the ground at all the above stations. Also, 6″ must be applied as is directed in Art. 146.

159. *Terrestrial Refractions.*

Between		Mean Refraction.
Maker and Kit Hill	- - -	$\frac{1}{7}$ of the contained arc.
Butterton and Kit Hill	-	$\frac{1}{8}$

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Between	Mean Refraction.
Bindown and Lansallos -	$\frac{1}{9}$ of the contained arc.
Nine Barrow Down and Black Down	$\frac{1}{10}$
Maker and Lansallos - -	$\frac{1}{10}$
Maker and the Bolt Head -	$\frac{1}{10}$
Carraton Hill and Bindown -	$\frac{1}{11}$
Karnbonellis and St. Buryan -	$\frac{1}{11}$
Maker and Bindown - -	$\frac{1}{12}$
Hensbarrow and the Deadman -	$\frac{1}{12}$
St. Agnes' Beacon and the Deadman	$\frac{1}{12}$
St. Agnes' Beacon and Karnminnis	$\frac{1}{12}$
Dumpdon and Cawsand Beacon -	$\frac{1}{13}$
Haldon and Cawsand Beacon -	$\frac{1}{13}$
Kit Hill and Bindown - -	$\frac{1}{13}$
Carraton Hill and Hensbarrow -	$\frac{1}{13}$
Lansallos and the Deadman -	$\frac{1}{13}$
Hensbarrow and St. Agnes' Beacon	$\frac{1}{13}$
Karnbonellis and Karnminnis -	$\frac{1}{14}$
* Furland and Haldon - -	$\frac{1}{15}$
Butterton and Maker - -	$\frac{1}{15}$
Butterton and Carraton Hill -	$\frac{1}{15}$
Maker and Carraton Hill -	$\frac{1}{15}$
Karnbonellis and the Deadman -	$\frac{1}{15}$
Karnbonellis and St. Agnes' Beacon	$\frac{1}{15}$
Karnminnis and St. Buryan -	$\frac{1}{15}$
Hensbarrow and Bodmin Down -	$\frac{1}{15}$
Lansallos and Bodmin - -	$\frac{1}{15}$
Butterton and the Bolt Head -	$\frac{1}{15}$
Haldon and Charton Common -	$\frac{1}{17}$
Rippin Tor and Cawsand Beacon	$\frac{1}{17}$
Black Down and Bull Barrow -	$\frac{1}{18}$
Black Down and Pilsden Hill -	$\frac{1}{18}$

Between	Mean Refraction.
Black Down and Charton Common -	$\frac{1}{18}$ of the contained arc.
Lansallos and Hensbarrow -	$\frac{1}{18}$
Rippin Tor and Haldon -	$\frac{1}{19}$
Butterton and Furland - -	$\frac{1}{19}$
Butterton and Rippin Tor - -	$\frac{1}{21}$
Kit Hill and Carraton - -	$\frac{1}{26}$
Pilsden Hill and Charton Common	$\frac{1}{28}$
Wingreen and Bull Barrow -	$\frac{1}{31}$
Lansallos and Carraton Hill -	$\frac{1}{34}$
Haldon and the Horizon of the Sea	$\frac{1}{11}$
Pilsden Hill and the Horizon of the Sea	$\frac{1}{11}$

160. *Table containing the Heights of the Stations.*

Stations.	Heights.
Black Down - -	817 feet.
Charton Common - -	582
Little Haldon - -	818
Rippin Tor - -	1549
Furland - - -	589
Butterton - -	1203
Maker Heights - -	402
Bull Barrow - -	927
Mintern Hill - -	891
Pilsden Hill - -	934
Dumpdon - -	879
Cawsand Beacon -	1792
Bolt Head - - -	430
Kit Hill - - -	1067
Bindown - -	658

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Stations.	Heights.
Carraton Hill - -	1208 feet.
Lansallos - -	514
Bodmin Down - -	649
Hensbarrow Beacon -	1026
The Deadman - -	379
St. Agnes' Beacon -	599
Karnbonellis - -	822
Karnminnis - -	805
St. Buryan - -	415

Remarks, &c. on the foregoing Table.

161. The height of the ground at the station on Maker Heights 402 feet, was determined by levelling down to low-water mark, near the passage-house, below Mount Edgcumbe, on April 15, 1796. This, however, had been done several years before, by some officers of the Royal Engineers, who found it to be 401 feet. The height of the station near Dunnose, in the Isle of Wight, was also found by levelling; of which an account is given in Art. 147. It therefore may be considered as the least exceptionable mode of procedure, to deduce the intermediate heights from both those stations; for which purpose, the following comparison was made, exhibiting the height of the station on Charton Common, both ways.

	Feet.
Height of Nine Barrow Down (149.) - -	642
of Black Down - - - - -	825
of Charton Common, *deduced from the height of* Dunnose - - - - -	597
of Butterton - - - -	1201
of Rippin Tor - - - -	1545

Height of Furland	- - - - - - -	585
of Haldon	- - - - - - -	811
of Charton Common, *deduced from the height of* Maker	- - - - - - -	568
	deduced from that of Dunnose	597
	difference	29

Those are the heights resulting directly from the observations. Now, supposing the difference, or the errors, to arise from the mean refractions, and those errors to be nearly the same between every two stations, we shall obtain the corrected heights in the following manner:

		Feet.	
Nine Barrow Down	$642 - 4 =$	638	
Black Down	$825 - 8 =$	817	as in the table.
Charton Common	$597 - 15 =$	582	
Butterton -	$1201 + 2 =$	1203	
Rippin Tor -	$1545 + 4 =$	1549	
Haldon -	$811 + 7 =$	818	
Charton Common	$468 + 14 =$	582	

From those corrected heights, the others to the northward have been deduced. The heights to the westward of Butterton were determined from that of Maker. A mean of two or three results, by using $\frac{1}{12}$ of the contained arcs for refraction, is taken for the height of the station on Mintern Hill.

162. *Secondary Triangles, in which two Angles only have been observed. The first three intersected places were selected for interior Stations, on account of their commanding situations.*

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
	° ′ ″		Feet.
Pilsden - Charton Common - *Golden Cape*	44 6 35 36 59 6	Golden Cape -	29848 34533
Rippin Tor - Cawsand Beacon - *Great Haldon*	88 2 28 41 22 57	Great Haldon -	54789 82829
Bolt Head - Maker Heights - *Hemmerdon Ball*	29 15 10 54 20 9	Hemmerdon Ball	82239 49464
Bull Barrow - Wingreen - *Noil Windmill*	109 12 12 33 45 11	Noil Windmill	63692 108255
Bull Barrow - Wingreen - *Noil Steeple*	22 4 38 111 10 59	Noil -	88420 35641
Bull Barrow - Wingreen - - *Holy Trinity Steeple, Shaftesbury*	18 16 15 65 39 45	Trinity Steeple	63275 21772
Bull Barrow - Wingreen - *St. Rumbold's Steeple, Shaftesbury* -	15 45 15 46 55 34	Rumbold Steeple	56778 21104
Bull Barrow - Wingreen - *Maypowder Steeple*	129 15 18 12 31 19	Maypowder -	24199 86426
Bull Barrow - Wingreen - *Stourhead House*	44 25 52 88 31 14	Stourhead House	94319 66050

	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
	Bull Barrow Nine Barrow Down *Mr. Frampton's Obelisk*	° ′ ″ 32 25 49 27 44 1	Frampton's Ob.	56980 65662
	Bull Barrow Mintern *Mere Steeple*	97 43 51 58 1 14	Mere	88095 102912
	Bull Barrow Mintern *Mrs. Thornhill's Obelisk*	68 44 5 47 19 3	Thornhill's Ob.	34902 44245
	Bull Barrow Mintern *Odcombe Steeple*	20 37 56 143 59 47	Odcombe	94589 56700
D	Bull Barrow Mintern *Milborne-port Steeple*	52 41 35 77 1 36	Milborne-port	54038 44107
D	Bull Barrow Mintern *Lord Poulett's Warren House*	7 39 0 132 19 30	Warren House	8829 49035
	Black Down Pilsden *Portland Light-house*	143 32 28 16 12 4	Light-House	63749 135775
	Black Down Pilsden *Naval-Signal-staff on Puncknoll*	32 55 8 13 35 5	Signal-staff	25615 59266
	Black Down Pilsden *House in Lambert's Castle*	9 2 48 62 47 53	Lambert's Castle	74048 13091
	Black Down Pilsden *Lyme Cobb*	26 6 41 92 54 15	Lyme Cobb	90349 39815

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Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
	° ′ ″		Feet.
Pilsden - - - Mintern - - *Glastonbury Tor*	64 47 55 78 12 22	Glastonbury Tor	127174 117551
Pilsden - - - Charton Common *Bridport Beacon, a Sea-mark*	40 30 43 62 0 1	Bridport Beacon	44332 32616
Pilsden - - - Charton Common *Barn on the high land near Sidmouth*	15 44 0 45 18 13	Barn, Sidm. Hill	39824 15191
Dumpdon - - Pilsden - - - *Naval-Signal-staff on Whitlands*	50 52 11 40 22 12	Signal-staff -	50832 60876
Dumpdon - - Pilsden - - - *Cothelstone Lodge, Quantock Hills*	93 52 54 37 51 16	Lodge -	64521 104901
Charton Common Dumpdon - - *Lord Lisburne's Obelisk on Haldon*	61 11 28 91 51 33	Obelisk on Haldon	127936 112161
Dumpdon - - Cawsand Beacon - *Sir J. de la Pole's Flag-staff, near Shute House*	128 45 59 13 59 24	Flagstaff -	72435 233619
Dumpdon - - Cawsand Beacon - *Honiton Steeple*	64 18 8 4 0 39	Honiton -	13650 175852
Dumpdon - - Cawsand Beacon - *St. Mary Ottery Steeple*	34 20 21 12 27 16	St. Mary Ottery	53653 140335

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
	° ′ ″		Feet.
Dumpdon - - Little Haldon - *Funnel on Sir R. Palk's Tower, Haldon*	17 20 53 63 7 37	Palk's Tower	114716 38347
Cawsand Beacon Little Haldon - D *North Bovey Steeple*	7 9 50 10 38 19	North Bovey	64313 43444
Little Haldon - Rippin Tor - - *Eastern Karn, or heap of stones, on the high ground near Moreton Hampstead*	34 8 22 66 14 23	Eastern Karn	52099 31944
Little Haldon - Rippin Tor - - *Western Karn, near Moreton Hampstead*	37 24 5 69 24 30	Western Karn	54751 35525
Little Haldon - Rippin Tor - *Naval-Signal-staff at West Down Beacon*	154 35 29 11 28 37	Signal-staff -	46268 99715
Little Haldon - Rippin Tor - - *Mr. Woodley's Summer House*	5 43 59 81 44 20	Summer House	55462 5598
Little Haldon - Rippin Tor - - *Naval-Signal-staff, Berry Head, Torbay*	99 46 2 42 35 24	Signal-staff -	62040 90345
Little Haldon - Rippin Tor - - *Brixen Steeple*	91 52 49 48 37 47	Brixen - -	66070 87993

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
	° ′ ″		Feet.
Little Haldon - Rippin Tor - - *Ipplepen Steeple*	67 8 45 44 56 5	Ipplepen -	42675 55677
Little Haldon - Rippin Tor - - *Three Barrow Tor, Dartmoor*	20 40 42 125 6 32	Three Barrow Tor	81460 35163
Furland - - Little Haldon - *Ruins on Brent Beacon*	71 56 33 51 46 15	Brent Beacon	68727 83180
Butterton - - Rippin Tor - - *Chudleigh Steeple*	17 4 21 136 27 46	Chudleigh -	97302 41471
Butterton - - Furland - - *Naval-Signal-staff at Coleton, near Froward Point*	3 37 11 140 5 47	Signal-staff -	87314 8593
Butterton - - Furland - - *Naval-Signal-staff, Start Point*	39 15 6 78 26 47	Signal-staff -	89129 57561
Butterton - - Furland - - *Marlborough Steeple*	61 55 7 48 18 25	Marlborough *Devon.*	64099 75736
Butterton - - Furland - - *Naval-Signal-staff, near the Bolt Head*	63 40 32 53 24 17	Signal-staff -	72632 81084
Butterton - - Maker - - *Highest Part of the Mewstone*	18 0 46 50 17 40	Mewstone -	62728 25213

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
	° ′ ″		Feet.
Butterton - - Maker Heights - *Cupola of the Royal Hospital, Plymouth*	6 11 21 44 49 37	Cupola, R. Hosp.	68709 10508
Butterton - - Maker Heights - *St. John's Steeple*	8 58 35 122 49 11	St. John's -	85401 15856
Butterton - - Maker Heights - *Saltash Steeple*	19 46 39 75 36 25	Saltash -	73708 25749
Butterton - - Maker Heights - *Penlee Beacon*	5 36 20 96 23 55	Penlee Beacon	76972 7566
Butterton - - Kit Hill - - *Plymstock Steeple*	39 1 33 27 49 38	Plymstock -	51259 69143
Butterton - - Kit Hill - - *Statten Barn*	48 3 55 35 25 31	Statten Barn	58906 75599
Butterton - - Kit Hill - - *Mount Batton*	41 56 57 37 8 33	Mount Batton	62087 68738
Butterton - - Kit Hill - - *Flagstaff in Plymouth Garrison*	39 56 31 34 45 12	Flagst. Plym. Gar.	59673 67207
Butterton - - Kit Hill - - *New Church Steeple at Plymouth*	37 21 59 33 0 38	New Church Steep.	58399 65058
Butterton - - Kit Hill - - *Old Church Steeple at Plymouth*	37 45 52 34 3 52	Old Church Steep.	59524 65081

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Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
	° ′ ″		Feet.
Butterton - - Kit Hill - - *West Chimney of the Governor's House, Plymouth Dock*	37 5 33 39 58 36	Governor's House	66558 62479
Butterton - - Kit Hill - - *Flagstaff in the Fort on Mount Wise*	37 6 53 40 42 48	Flagstaff, Mount Wise	67374 62327
Butterton - - Kit Hill - - *Steeple of the Chapel, Plymouth Dock*	35 14 20 41 25 1	Chapel, Ply. Dock	68653 59874
Butterton - - Kit Hill - - *Flagstaff in St. Nicholas' Island*	41 40 8 38 38 52	Flagstaff,St.Ni.Isl.	63970 68097
Butterton - - Kit Hill - - *Obelisk at Crimbill Passage*	38 40 39 42 48 20	Obelisk -	69376 63803
Butterton - - Kit Hill - - *East Pinnacle on Mount Edgcumbe House*	40 29 28 42 49 3	Mount Edg. House	69096 66012
Butterton - - Kit Hill - - *Flagstaff on Maker Tower*	41 54 7 45 25 27	Maker Tower	72001 67507
Butterton - - Kit Hill - - *Naval-Signal-staff, near Maker Tower*	41 53 45 45 35 55	Signal-staff -	72207 67490
Butterton - - Kit Hill - - *Chestow Steeple*	12 40 29 138 21 13	Chestow - -	138522 45738

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Triangles.	Angles observed.	Distances of the stations fom the intersected objects.	
	° ′ ″		Feet.
Butterton - - Carraton Hill - - *Stonehouse Steeple*	40 34 1 23 29 2	Stonehouse -	58310 95162
Butterton - - Carraton Hill - *Obelisk at Puslinch*	60 48 52 16 41 16	Puslinch Obelisk	38700 117659
Butterton - - Carraton Hill - *Rame Head*	41 2 54 39 30 40	Rame Head -	84846 87594
Kit Hill - - Maker Heights - *Brent Tor, near Lydford*	116 24 26 24 3 10	Brent Tor -	43421 95419
Kit Hill - - Maker Heights - *Flag-staff of the Block House, near Dock*	11 30 56 46 26 51	Block House -	57984 15972
Kit Hill - - Maker Heights - *Rame Steeple*	4 3 42 141 4 23	Rame -	74547 8403
Carraton Hill - Maker Heights - *Steeple of the Chapel in the Yard, Plymouth Dock*	7 28 15 64 48 50	Dock-yard Chapel - -	78468 11274
Carraton Hill - - Maker Heights - *Windmill at Plymouth Dock*	7 34 6 71 29 35	Windmill at Dock	79778 11080
Carraton Hill - - Maker Heights - *Battery on Statten Heights*	7 31 7 133 32 55	Statten Battery	97488 17199
Kit Hill - - Carraton Hill - - *St. Stephen's Steeple*	105 0 39 43 47 30	St. Stephen's - *near Saltash.*	44659 62330

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Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
	° ′ ″		Feet.
Kit Hill - - Carraton Hill - *St. Ive Steepl e*	29 11 14 47 42 54	St. Ive -	25390 16736
Kit Hill - - Carraton Hill - *Callington Steeple*	42 31 4 10 20 54	Callington -	7532 28336
Kit Hill - - Carraton Hill - *Linkinborn Steeple*	25 20 11 28 8 55	Linkinhorn -	19621 17798
Kit Hill - - Carraton Hill - D *St. Dominic Steeple*	121 48 23 9 59 38	St. Dominic -	7776 38097
Kit Hill - - Carraton Hill - D *South Petherwin Steeple*	60 22 24 67 55 47	South Petherwin	39475 37027
Kit Hill - - Carraton Hill - *Sauth Hill Steeple*	19 31 2 15 22 32	South Hill -	15493 19522
Kit Hill - - Carraton Hill - *Lord Mount Edgcumbe's House, at Empercombe*	108 14 2 48 46 11	House at Empercombe -	64348 81266
Kit Hill - - Carraton Hill - *Northern Sea-Mark on the Hoe*	59 59 7 42 59 43	Sea-Mark -	66387 87011
Kit Hill - - Bindown - *St. Cleer Steeple*	39 56 21 51 25 10	St. Cleer -	42931 35256
Carraton Hill - Bindown - - *The Highest part of Brownwilly*	130 14 2 26 32 44	Brownwilly -	48221 82371

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Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
	° ′ ″		Feet.
Carraton Hill - Bindown - - *Cheese Rings*	138 42 49 7 21 53	Cheese Rings	9773 50300
Carraton Hill - Bindown - - *Liskeard Steeple*	18 2 57 17 6 59	Liskeard -	21739 22885
Carraton Hill - Bindown - - *Duloe Steeple*	18 6 21 84 32 47	Duloe - -	43403 13550
Carraton Hill - Bindown - - *Menheniot Steeple*	9 16 26 14 32 34	Menheniot -	21502 13806
Carraton Hill - Bindown - - *Landrake Steeple*	43 17 44 75 46 11	Landrake -	47177 33376
Carraton Hill - Bindown - - *Naval-Signal-staff at Nealand, near Polparrow*	22 51 23 129 59 13	Signal-staff -	36203 71413
Carraton Hill - Lansallos - - *Boconnock Steeple*	25 5 53 35 41 57	Boconnock -	46079 33495
Carraton Hill - Lansallos - - *Obelisk at Boconnock, (Lord Camelford's)*	24 4 10 41 27 47	Boconnock Ob.	50139 30886
Carraton Hill - Lansall s - - *Roach Rock*	41 29 10 94 48 32	Roach Rock -	99410 66086
Carraton Hill - Lansallos - - *Roach Steeple*	42 1 28 94 41 58	Roach -	100214 67314

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
	° ′ ″		Feet.
Lansallos - Hensbarrow Beacon *Helmen Tor*	21 34 34 46 16 45	Helmen Tor -	48412 24633
Lansallos - Hensbarrow Beacon *Mr. Tremaine's Summer House*	37 8 29 70 7 42	Summer House	61105 39231
Lansallos - Hensbarrow Beacon *Gorran Steeple*	45 34 10 72 3 29	Gorran - -	66624 50008
Lansallos - Hensbarrow Beacon *Naval-Signal-staff on the Deadman*	52 43 25 71 28 51	Signal-staff -	71136 59696
Lansallos - Hensbarrow Beacon *Gwineas Rocks*	51 21 9 60 17 27	Gwineas Rocks, off Mevagissy	57977 52133
Bodmin Down - Hensbarrow Beacon *Hendellion Steeple*	97 21 30 39 57 45	Hendellion -	44851 69255
Bodmin Down - Hensbarrow Beacon *The high Stone on St. Braeg Down*	48 38 46 55 1 58	Stone, St. Braeg D.	39924 36571
Bodmin Down - Hensbarrow Beacon *St. Dennis Steeple*	13 28 31 120 37 11	St. Dennis -	56722 15359
Bodmin Down - Hensbarrow Beacon D *Lansallos Steeple*	64 55 8 68 45 47	Lansallos -	61011 59285
Deadman - - Lansallos - D *St. Veep Steeple*	12 51 38 73 45 53	St. Veep - -	67986 15761

	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
		° ′ ″		Feet.
D	Lansallos - Bodmin Down - *Lanlivery Steeple*	26 19 35 33 51 19	Lanlivery -	39552 31486
D	Hensbarrow Beacon Deadman - *Gerrans Steeple*	30 50 7 106 31 21	Gerrans -	83901 44858
D	Hensbarrow Beacon Deadman - *St. Michael Carhayes Steeple*	13 56 6 43 10 53	Carhayes -	48309 17001
	Hensbarrow Beacon Deadman - *St. Kivern Steeple*	31 22 22 128 53 52	St. Kivern -	136676 91426
	Hensbarrow Beacon Deadman *Naval-Signal-Staff at Black Head*	29 6 51 133 59 31	Signal-staff -	146770 99260
	Hensbarrow Beacon Deadman - *Windmill near Fowey*	62 46 29 45 59 37	Fowey Windmill	45036 55677
	Hensbarrow Beacon Deadman - *Menabilly House*	56 10 33 36 24 22	Menabilly -	35221 49300
	Hensbarrow Beacon Deadman - *Old Tower at Polruan*	60 28 23 49 6 10	Tower, Polruan	47561 54749
	Hensbarrow Beacon Deadman - *Naval-Signal-staff at St. Anthony's Head*	30 52 0 116 42 13	Signal-staff -	98759 56717
D	Hensbarrow Beacon St. Agnes' Beacon *St. Columb Minor Steeple*	31 37 12 28 56 16	St. Columb Minor	53942 58448

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Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
	° ′ ″		Feet.
D Hensbarrow Beacon St. Agnes' Beacon *Peranzabulo Steeple*	11 43 0 31 9 39	Peranzabulo -	73829 28975
Hensbarrow Beacon St. Agnes' Beacon *St. Eval Steeple*	57 24 41 35 11 34	St. Eval -	56011 81884
Hensbarrow Beacon St. Agnes' Beacon *Cubert Steeple*	15 2 26 30 37 20	Cubert -	69141 35224
Hensbarrow Beacon St. Agnes' Beacon *Flagstaff in Pendennis Castle*	41 44 14 72 36 24	Pendennis Castle	101687 70938
Hensbarrow Beacon St. Agnes' Beacon *Windmill near St. Mawes*	42 11 25 61 3 38	St. Mawes' Windmill -	87286 66985
St. Agnes' Beacon Karnminnis - *Karnbury Castle*	49 20 11 20 23 49	Karnbury Castle	31435 68417
St. Agnes' Beacon Karnminnis - *Cupola of the Market House in Redruth*	55 59 58 17 46 35	Cupola in Redruth	26903 73054
St. Agnes' Beacon Karnminnis - *Camborn Steeple*	30 57 7 21 45 40	Camborn -	39427 54696
St. Agnes' Beacon Karnminnis - *Illugan Steeple*	31 12 56 10 49 6	Illugan -	23718 65490
St. Agnes' Beacon Karnminnis - *St. Paul Steeple*	40 52 42 117 47 27	St. Paul -	110564 81794

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
St. Agnes' Beacon Karnminnis - *Lord de Dunstanville's House*	° ′ ″ 20 40 33 10 47 12	Dunstanville House -	30339 57237
St. Agnes' Beacon Karnminnis - D *Gwinear Steeple*	21 40 24 40 30 44	Gwinear -	62144 35330
St. Agnes' Beacon Karnminnis - *Mr. Kneil's Obelisk, near St. Ives*	53 24 45 88 37 42	Mr. Kneil's Ob.	73889 59346
St. Agnes' Beacon Karnminnis - *Highest of the Rocks called the Cow and Calf*	141 53 34 20 9 34	Cow and Calf Rocks -	94650 169450
St. Agnes' Beacon Karnbonellis - *St. Erme Steeple*	94 43 5 42 10 34	St. Erme -	44668 66303
St. Agnes' Beacon Karnbonellis - *St. Allen Steeple*	98 13 52 35 41 11	St. Allen -	36816 62462
St. Agnes' Beacon Karnbonellis - *Ludgvan Steeple*	44 12 31 105 49 41	Ludgvan -	87573 63469
Karnminnis - Karnbonellis - *Windmill near the Lizard*	41 26 59 95 31 22	Lizard Windmill	104413 69440
Karnminnis - Karnbonellis - *Grade Steeple*	40 7 0 100 25 15	Grade -	110762 72566
Karnminnis - Karnbonellis - *Ruan Major Steeple*	38 32 27 97 30 19	Ruan Major -	102243 64256

Triangles.		Angles observed.	Distances of the stations from the intersected objects.	
		° ′ ″		Feet.
	Karnminnis -	39 52 32	St. Hilary -	33808
	Karnbonellis -	25 24 25		50519
	St. Hilary Steeple			
	Karnminnis -	10 0 52	Castle Dennis	69233
	Karnbonellis -	74 13 53		15749
	Castle Dennis (Mr. Rogers's Tower)			
	Karnbonellis -	9 32 41	Madern -	80908
	St. Buryan -	33 51 25		24081
	Madern Steeple			
	Karnbonellis -	60 38 57	Perranuthno -	38552
	St. Buryan -	49 18 46		44315
D	*Perranuthno Steeple*			
	Karnbonellis -	76 57 1	Girnhove -	46355
	St. Buryan -	50 25 43		58583
D	*Girnhove Steeple*			
	Karnbonellis -	60 25 48	Signal-staff -	66344
	St. Buryan -	40 43 1		88458
	Naval-Signal-staff, Park Loughs			
	Pertinney -	116 12 46	St. Buryan -	12751
	Karnminnis -	13 40 7		48411
	St. Buryan Steeple			
	St. Buryan -	23 28 57	Chapel Karnbury	10728
	Pertinney -	58 34 54		5009
	Chapel Karnbury			
	St Buryan -	75 36 7	Signal-staff -	20094
	Pertinney -	67 31 4		19169
	Naval-Signal-staff, St. Leven's Point			
	St. Buryan -	69 21 10	Sennen -	17475
	Pertinney -	68 58 0		17520
	Sennen Steeple			

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
	° ′ ″		Feet.
Sennen - -	106 43 44	Stone, Land's End	2791
Pertinney - -	7 15 12		21173
*Stone near the Land's End**			
Sennen - -	126 1 11	Light-house -	10717
Pertinney - -	18 6 39		27883
Longship's Light-house			

163. *Triangles for ascertaining the Distances of the Eddystone Light-house, from the Flagstaff of Plymouth Garrison, and the Rame-head.*

The ball on the lantern of the Light-house was observed from the stations on Butterton, Kit Hill, and Carraton Hill; and as much uncertainty has heretofore existed, with respect to a knowledge of its true distance from any point in the neighbourhood of Plymouth, observations were made on various arcs of the circle of the instrument at the two first stations.

The triangles are the following.

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
	° ′ ″		Feet.
Butterton - -	66 46 21	Light-house -	121159
Kit Hill - -	64 27 46		123399
Eddystone Light-house			
Butterton - -	60 5 31	Light-house -	121158
Carraton Hill -	55 52 41		126863
Eddystone Light-house			

* A large rough stone on the right hand, near the path, about 300 yards before you get down to the rocks at the Land's End.

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With the distance of the Eddystone Light-house from Kit Hill, and also that of the Flagstaff in Plymouth garrison from the same station, we find the distance from the Light-house to the Flagstaff = 73061 feet;* the observed angle being 29° 42′ 34″: and, computing with the *data* obtained from the last triangle, and the third in page 394, with the observed angle at Carraton Hill = 16° 22′ 1″, we get 49435 feet for the distance of the Eddystone Light-house from the building on Rame-head. It may be proper to observe, that the Eddystone Light-house is nearer to the Rame-head than to any other point on the coast.

164. *Triangles for ascertaining the Situations of the Lizard Light-houses, and the Lizard Point.*

Distance from Karnbonellis to Pertinney 101474 feet.

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
Karnbonellis - Pertinney - - *Eastern Light-house*	78° 49′ 28″ 42 56 51	Eastern Light-house -	81323 117097
Karnbonellis - Pertinney - - *Western Light-house*	78 40 5 43 0 53	Western Light-house -	81348 116921
Karnbonellis - Pertinney - - *Naval-Signal-staff*	78 8 57 42 28 45	Signal-staff -	79635 115408
Karnbonellis - St. Buryan - - *Naval-Signal-staff*	71 7 19 45 30 56	Signal-staff -	79645 105873

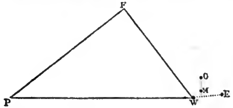
* On referring to the late Mr. Smeaton's Narrative of the Building of the Eddystone Light-house, it will be found, that, from a trigonometrical process, founded on two

From the two last triangles we obtain 79640 feet for the mean distance between the Lizard Signal-staff and the station on Karnbonellis. Computing with this distance, and also that from the Western Light-house to the same station, with the observed angle 0° 31′ 8″, we get 1857 feet for the distance between those objects.

For the purpose of ascertaining the situation of the Lizard Point, two angles in the following triangle were observed with a sextant, viz.

		°	′
Naval-Signal-staff	-	77	4
Western Light-house	-	60	50
Lizard Point.			

These, with the computed distance from the Signal-staff to the Light-house, give the distance of the Lizard Point from the $\left\{\begin{matrix}\text{Signal-staff} & 2419\\ \text{Light-house} & 2700\end{matrix}\right\}$ feet. Hence, the distance of the point from the station on Karnbonellis is 81085 feet, the angle at that station, between the Lizard Point and Western Light-house, being 1° 53′ 47″. With respect to the means by which the situation of the spot on which Mr. Bradley erected his observatory in 1769, may hereafter be determined, it will be readily understood from the following diagram; where E is the Eastern Light-house, W the Western Light-house, F the Signal-staff, P the Lizard Point,



bases measured on the Hoe, among other deductions, he concluded the distance between the above objects was 73464 feet: being 403 greater than the distance found by the above computation.

and O the place of the Observatory. The distance between the spot O, and M,* the place where his meridian mark was fixed, we measured and found = 520 feet; M being 24 feet north of the line joining the centres of the Light-houses.

165. *Distances of the Day-Mark, St. Agnes' Light-house, and other Objects in the Scilly Isles, from particular Stations in the West of Cornwall.* Pl. XXI. †

Observations made at Karnminnis.

Between	°	′	″	Mean. ″
The station at St. Buryan and the Day-Mark	39	3	22$\frac{3}{4}$	23
			22$\frac{3}{4}$	
			23$\frac{3}{4}$	
At St. Buryan.				
Karnminnis and the Day-Mark - -	129	52	22	22
			22$\frac{1}{4}$	
Pertinney and St. Agnes' Light-house -	83	59	51$\frac{3}{4}$	51
			50	
Flagstaff of the Fort in St. Mary's and Karnminnis - - - -	134	39	45$\frac{3}{4}$	45$\frac{1}{2}$
			45	
Windmill in St. Mary's and Pertinney -	84	23	53$\frac{1}{2}$	53$\frac{1}{4}$
			53	
At Pertinney.				
St. Agnes' Light-house and Karnminnis -	92	6	20	21$\frac{3}{4}$
			21$\frac{1}{4}$	
			21$\frac{1}{2}$	
			23$\frac{1}{2}$	

* The person spoken of in Art. 154. as having the care of the Light-houses, pointed out this spot.

† The triangles for this purpose are laid down in a detached position, to shorten the plan.

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Between	°	′	″	Mean.
Day-Mark and Karnminnis - -	148	11	8½ 10¼	″ 9¼
Flagstaff in St. Mary's and St. Buryan -	93	47	18	
Windmill in St. Mary's and St. Buryan -	92	26	33	
At Sennen.				
Day-Mark and Pertinney - - -	145	20	8½ 10	9¼
St. Agnes' Light-house and Pertinney -	152	43	24 24½	24¼

From those observations, result the following triangles, when the necessary corrections are applied for reducing the observed angles to those formed by the chords, *viz.*

Triangles.	Observed angles corrected.	Distances of the stations from the intersected objects.	Feet.
Karnminnis - St. Buryan - - *Day-Mark*	° ′ ″ 39 3 24 129 52 19	Day-Mark -	190985 156796
Karnminnis - Pertinney - - *Day-Mark*	25 15 8 148 11 5	Day-Mark -	190989 154551
Sennen - - Pertinney - - *Day-Mark*	145 20 7 30 24 7	Day-Mark -	137526 154568
Sennen - - Pertinney - - *St. Agnes' or the Scilly Light-house*	152 43 20 24 21 55	Scilly Light-house	164010 182199
St. Buryan - - Pertinney - - *St. Agnes' Light-house*	83 59 51 92 6 22	Scilly Light-house	183096 182215

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Triangles.	Observed angles corrected.	Distances of the stations from the intersected objects.	
	° ′ ″		Feet
St. Buryan -	83 24 53	Windmill -	172183
Pertinney - -	92 26 33		171203
Windmill in St. Mary's			
St. Buryan -	82 8 18	Flagstaff -	174890
Pertinney - -	93 47 18		173626
Flagstaff of the fort in St. Mary's			

The distance from the Day-Mark to Karnminnis, as obtained from the first triangle, is 190985 feet, and by the second, 190989 feet, which differs only 4 feet from the former; and by the second and third triangles, the difference of the distances from the same object, to the station on Pertinney, is 17 feet; which, allowing for the shortness of the bases, must be considered as trifling. We may presume, therefore, that had not the Day-Mark been seen from Karnminnis, but from Sennen and Pertinney alone, the observations from which the angles of the third triangle are derived, would have afforded the means of computing the distance with sufficient precision. In like manner the fourth and fifth triangles seem to prove, that the observations made to St. Agnes' Light-house were sufficiently accurate, as there is a difference only of 16 feet between the distances of the Light-house from Pertinney. The ball on the top of the Light-house was the object always observed; and the Day-Mark being pyramidical, we had the means of making the observations at the different stations to the same point of that building.

166. *Distances of the Objects in the Scilly Isles, (intersected from the Stations in the West of Cornwall) from Sennen Steeple; the Stone near the Land's End; and the Longship's Light-house.*

As the observations made to the Day-Mark, and St. Agnes' Light-house, may be supposed sufficiently accurate; and the ball on the top of the Longship's Light-house was also observed under favourable circumstances, it will be proper to apply the corrections to the horizontal angles, in order to obtain those formed by the chords. Taking, therefore, Pertinney as the angular point, and computing with the following *data, viz.*

Station on Pertinney from -	Day-Mark - -	= 154551	Feet. And
	Scilly Light-house -	= 182207	
	Longship's Light-house	= 27883	

the angle at Pertinney, augmented for calculation, between the Longship's Light-house and -	the Day-Mark -	= 12° 17′ 30″	We get the distance of
	Scilly Light-house	= 6 15 25	

the Longship's Light-house from -	the Day-Mark - -	= 127446 feet	= 24.14	Miles.
	Scilly Light-house -	= 154519 feet	= 29.06	

Calculating also, with the distances of the two other objects in the Scilly Isles, and likewise those of Sennen Steeple, and the Stone near the Land's End from Pertinney, with the included angles at the same station, we get

		Feet.	Miles.
Sennen Steeple from -	Day-Mark - - -	= 139521	= 26.43
	Scilly Light-house -	= 166255	= 31.49
	Flagstaff in St. Mary's	= 157912	= 29.95
	Windmill in St. Mary's	= 155299	= 29.41
Stone near the Land's End from -	Day-Mark - -	= 135343	= 25.63
	Scilly Light-house -	= 162100	= 30.7
	Flagstaff in St. Mary's	= 153744	= 29.11
	Windmill in St. Mary's	= 151138	= 28.63

Of the Scilly Isles, Menawthen is the nearest to the Land's End, being about $1\frac{2}{10}$ miles eastward of the Day-Mark; and the cluster of rocks, called the Bishop and his Clerks, the most remote, being $3\frac{1}{3}$ miles west of St. Agnes' Light-house. Combining, therefore,

the above particulars with those distances, we may conclude, that the nearest part of the Scilly Isles is about 24.7 miles from the Land's End, and the farthest nearly 34.

Account of a Trigonometrical Survey carried on in Kent, in the Years 1795, and 1796, with the small circular Instrument. Pl. XXII.

167. *Particulars respecting the Instrument.*

The instrument used in this Survey was made by Mr. Ramsden; and is about half the size of his large theodolite, or circular instrument, with which we take the horizontal angles, but nearly similar to it in all its parts; consequently a very brief description will be sufficient.

The most material variations in the construction are,

1. The levelling or feet screws. These are below that horizontal movement which serves to direct the lower telescope to any particular object. By this position of the screws, the horizontal circle being once made level, the whole instrument may be moved round without disturbing its horizontality; the levelling screws remaining stationary during that operation, which cannot be done in the large instrument, because the screws are carried round with it.

2. The diameter of the horizontal circle being only half that of the larger one, it follows, that the space between any two dots on the limb, gives double the number of minutes that are contained in the same space on the greater circle: on this account, each revolution in the micrometer screw in the microscope answers to 2′; and the circle on the microscopic micrometer being divided into 60 parts, each division becomes equal to 2″, but for the convenience of notation, they are numbered at every 5th, with 10, 20, &c. to 50, the 60th being marked 1, to denote 1′: the number of seconds

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then commencing as before, the whole revolution becomes 2′. The revolutions are counted by means of notches on one side of the field in the microscope, in the same manner as in those of the large instrument.

3. This instrument not being intended for determining the direction of the meridian, a vertical semicircle for directing the telescope to the pole star became unnecessary; yet some apparatus was required, whereby small elevations or depressions from the horizon might be ascertained with a tolerable degree of precision. For this purpose, a moveable index, of about four inches long, is made to turn on the horizontal axis of the upper telescope, and so constructed, that by means of a finger screw, it can be fixed firmly in any position. The lower end of this index is furnished with a steel micrometer screw, having a circle on its head, divided into 100 parts, for shewing the fractional parts of a revolution, while other divisions, on a chamfered edge of the index which marks the fractional parts, give the number of revolutions made by the micrometer screw.

The method of finding the value of a revolution of the micrometer head in parts of a degree, &c. was as follows:

A rod, 14 or 16 feet long, was placed horizontally about three quarters of a mile off, and the angle subtended by its ends measured with the instrument in the usual way: the rod was then set up perpendicular at the same place, and the cross wires in the telescope directed to one of its extremities: the telescope was then moved in the vertical plane, by means of the micrometer screw, till the cross wires coincided with the other extremity. In this manner, by counting the number of revolutions, &c. necessary to move the telescope from one position to the other, an angle was measured vertically with the micrometer screw, equal to the former horizontal angle. From repeated trials, the value of a revolution was found equal to 10′ 27″.

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This instrument, on account of its portable size, may very readily be taken to the tops of steeples, towers, &c. and is, therefore, extremely well adapted to the uses for which it was intended.

Stations. 1795.

168. *Folkstone Turnpike,* the station in 1787.

Hawkinge, about three quarters of a mile from Folkstone Turnpike. This station was chosen for the purpose of having a view of the Belvidere in Waldershare Park, which cannot be seen from the station of 1787.

Dover Castle.

Paddlesworth; about 400 feet from the station of 1787. This new spot was selected, because Hardres Steeple is not visible from the old station.

Waldershare; on the Belvidere in the Earl of Guilford's Park.

On *Ringswold,* or *Kingswould Steeple.*

On a sand hill near the sea shore, between Deal and Ramsgate: this station is denominated *Shore.*

Near *Mount Pleasant House,* Isle of Thanet.

On a rising ground near *Wingham.*

On *Chislet* Steeple.

In *Beverley Park,* near Canterbury.

On Upper *Hardres* Steeple.

Triangles for determining the Distances of the Stations.

169. As the station on the Keep of Dover Castle, in 1787, was directly over the steps of the Turret, a new point was chosen about $6\frac{1}{2}$ feet from the former, where the instrument could stand conveniently: this new point is about 2.8 feet farther from Folkstone

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Turnpike, and 1 foot farther from Paddlesworth, than the point marking the old station.

	Feet.	
Dover Castle from Folkstone Turnpike	31556	page 146.
from Paddlesworth	42563	

Hence, the new point on Dover Castle from Folkstone Turnpike - - - -

stone Turnpike	31558.8	feet.
from Paddlesworth	42564	

In order to obtain the distance between Waldershare and Dover Castle from those new sides, or distances, the three angles of the following triangle were very carefully taken:

	° ′ ″	° ′ ″	
Dover Castle	3 49 16	3 49 15	for computation.
Folkstone Turnpike	36 6 31	36 6 30	
Hawkinge	140 4 16	140 4 15	
	180 0 3		

The third angles of the two next triangles were not observed:

	° ′ ″
Hawkinge	44 23 30
Dover Castle	73 53 44
Waldershare	61 42 46
Dover Castle	62 24 7
Paddlesworth (the station of 1787)	32 36 9
Waldershare	84 59 44

	Feet.	
By the two first triangles, Dover Castle from Waldershare -	23019.4	23020.5 mean distance.
From the latter - - -	23021.5	

And *Hawkinge* from	Dover Castle	28976
	Waldershare	31616

N. B. In all the following triangles, the angles at the stations, or objects, denoted in *italics*, are supplemental, or were not observed. And it is also to be remarked, that whenever Paddlesworth is mentioned hereafter, the *new station* is to be understood.

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Names of stations.	Angles. ° ′ ″	Distances.		Feet.
Waldershare	85 2 25	Paddlesw. from	Dover	42239
Paddlesworth	32 53 10		Waldershare	37460
Dover -	62 4 25			
Waldershare	57 1 15	Hardres	Waldershare	43548
Paddlesworth	69 21 59		Paddlesworth	39035
Hardres -	53 36 46			
Dover -	66 46 45	Ringswold	Dover -	23745
Waldershare	57 57 24		Waldershare	25743
Ringswold	55 15 51			
	180 0 0			
Waldershare	45 43 8	Shore	Waldershare	42755
Ringswold	97 38 32		Ringswold -	30883
Shore -	36 38 20			
Mount Pleasant	40 53 17	Mt. Pleasant	Shore	30635
Shore -	111 8 27		Waldershare	60920
Waldershare	27 58 16			
Mount Pleasant	31 55 12	Wingham	Mt. Pleasant	33459
Wingham -	119 32 5		Waldershare	37031
Waldershare	28 32 43			
Mount Pleasant	38 32 17	Chislet	Mount Pleasant	30062
Chislet -	79 25 36—35		Wingham -	21206
Wingham -	62 2 8			
	180 0 1			
Hardres -	52 46 14	Hardres from Wingham		39322
Wingham -	69 29 1			
Waldershare	57 44 55			
Wingham -	50 4 0	Beverley Park	Wingham	33320
Beverley Park	75 0 0		Hardres	31215
Hardres -	54 56 4—0			
	180 0 4			

170. *Secondary Triangles.*

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
Paddlesworth - Waldershare - *Barham Windmill*	38° 28′ 36″ 70 22 24	}Windmill - {	37283 24628
Dover - - Waldershare - - *St. Radigund's Abbey*	51 40 11 44 23 40	}Abbey - - {	16196 18160
Dover - - Waldershare - - *Hougham Steeple*	75 15 45 40 31 40	}Hougham - - {	16614 24726
Dover - - Waldershare - - *Gunston Steeple*	32 41 51 17 46 31	}Gunston - {	9111 16123
Dover - - Waldershare - - *St. Margaret's Steeple*	88 19 36 32 34 23	}St. Margaret's {	14444 26817
Hawkinge - - Waldershare - - *Elham Windmill*	84 50 30 15 3 14	}Windmill - {	8335 31963
Dover - - Ringswold - - *South Foreland Light-house*	39 48 39 28 8 7	}Light-house - {	12081 16403
Waldershare - - Ringswold - - *Upper Deal Windmill*	17 10 7 102 11 7	}Windmill - {	28870 8718
Waldershare - - Ringswold - - *Upper Deal Chapel*	22 20 10 100 38 27	}Deal Chapel - {	30160 11663
Waldershare - Ringswold - - *Lower Deal Windmill*	19 1 31 110 21 19	}Windmill - {	31226 10857
Waldershare - Ringswold - *Deal Castle*	19 28 27 121 2 45	}Deal Castle - {	34689 13498

Triangles.	Angles observed.	Distances of the stations fom the intersected objects.	
			Feet.
Waldershare - - Ringswold - - *Norbourn Windmill*	42° 26′ 26″ 57 41 19	Windmill -	22102 17648
Waldershare - Ringswold - - *Watch-house near the sea shore*	9 19 40 135 28 3	Watch-house	31317 7238
Waldershare - Ringswold - - *Sandown Castle*	29 45 47 111 20 13	Sandown Castle	38185 20351
Waldershare - Ringswold - - *Walmer Steeple*	12 29 13 115 33 51	Walmer -	29491 7069
Waldershare - Ringswold - - *Ripple Steeple*	15 35 53 69 33 23	Ripple - -	24209 6947
Waldershare - - Ringswold - *Waldershare Steeple*	20 45 23 5 35 50	Waldershare -	5656 20552
Waldershare - - Shore - - *Eastry Steeple*	16 23 49 21 57 46	Eastry - -	25766 19448
Waldershare - - Shore - - *Ash Steeple*	35 10 6 56 41 26	Ash - -	35750 24639
Waldershare - - Shore - - *Minster Steeple*	28 29 39 103 15 30	Minster -	55782 27341
Waldershare - Shore - - *Woard Steeple*	5 43 2 19 37 24	Woard - -	33548 9951
Waldershare - - Shore - - *Sandwich, highest Steeple*	13 35 31 59 30 36	Sandwich -	38505 10501

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Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
	° ′ ″		Feet.
Ringswold - Shore - - *Mongeham Steeple*	24 46 49 13 3 56	Mongeham -	11379 21098
Ringswold - - Shore - - *Norbourn Steeple*	35 9 0 25 59 2	Norbourn -	15450 20303
Ringswold - - Shore - - *Woodnessborough Steeple*	33 7 44 77 48 16	Woodnessborough	32320 18071
Shore - - Mount Pleasant - *Ramsgate Windmill*	41 10 35 47 47 27	Windmill -	22695 20173
Shore - - Mount Pleasant - *St. Lawrence Steeple*	36 26 58 54 52 36	St. Lawrence	25064 18205
Waldershare - - Mount Pleasant - *Wingham Steeple*	32 2 55 31 1 14	Wingham -	35214 36259
Waldershare - - Mount Pleasant - *Goodneston Steeple*	31 12 40 17 58 32	Goodneston -	24841 41711
Mount Pleasant - Chislet - - *Birchington Steeple*	77 19 0 22 10 4	Birchington -	11500 29735
Mount Pleasant - Chislet - - *St. Nicholas Steeple*	19 36 3 21 19 41	St. Nicholas -	16690 15394
Mount Pleasant - Chislet - - *Stormouth Steeple*	16 56 56 33 29 54	Stormouth -	21519 11366
Mount Pleasant - Chislet - - *Reculver Windmill*	22 14 40 81 14 59	ReculverWindm.	30556 11703

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Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
Mount Pleasant - Wingham - - *South Reculver*	69° 57′ 57″ 51 54 46	South Reculver	31012 37017
Mount Pleasant - Wingham - - *Hearne Windmill*	50 51 41 78 50 42	Windmill -	42669 33732
Wingham - - Waldershare - *Littlebourn Steeple*	102 34 17 11 3 35	Littlebourn -	7752 39442
Wingham - - Chislet - - *Blean Steeple*	58 30 34 88 52 9	Blean - -	39329 33544
Wingham - - Chislet - *Wickham Steeple*	59 11 7 24 25 37	Wickham -	8824 18326
Wingham - - Chislet - - *Ickham Steeple*	72 3 26 22 6 13	Ickham -	8001 20228
Wingham - - Beverley Park - - *Bridge Windmill*	47 35 34 44 59 50	Bridge Windmill	23584 24628
Wingham - - Beverley Park - *Nackington Steeple*	33 27 20 68 29 54	Nackington -	31688 18776
Wingham - - Hardres - - *Chillendon Windmill*	80 53 7 21 53 16	Windmill -	15031 39811
Wingham - - Hardres - - *Preston Steeple*	122 1 10 8 3 28	Preston -	7220 43572
Wingham - - Hardres - - *Shottenden Windmill*	30 49 24 118 30 8	Windmill -	67736 39494

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
	° ′ ″		Feet.
Hardres - Beverley Park - *St. Martin's Windmill*	11 35 23 27 48 16	}St. Martin's Wind.{	22943 9881
Hardres - Beverley Park - *Harbledown Steeple*	12 11 37 39 25 30	}Harbledown - {	25289 8411
Hardres - Beverley Park - *Sturry Steeple*	17 29 59 84 3 53	}Sturry - - {	31691 9581
Waldershare - Hardres - *Canterbury Cathedral*	24 29 21 105 36 14	}Canterbury Cath. {	54827 23597
Hardres - Paddlesworth - *West-Stone-Street Wind-mill*	40 45 34 27 23 18	}Windmill - {	19347 27458
Hardres - Paddlesworth - *Stelling Windmill*	31 0 20 15 3 20	}Stelling Windmill {	14081 27924

Triangles carried over another part of Kent in 1795.

171. On account of the high woody lands to the westward of Hardres and Paddlesworth, the triangles could not be extended in that direction, and therefore the following may be considered as a detached part of the Survey this year.

The Stations were,

Westwell Down,
Wye Down,
Brabourn Down,
Allington or *Aldington Knoll*, the station in 1787.

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Allington Knoll from Tenterden Steeple (triang. XIX. p. 144), is $61777\frac{1}{2}$ feet. The centre of the top of Tenterden Steeple is about 4 or $4\frac{1}{2}$ feet farther from Allington Knoll than the point marking the station in 1787; therefore the distance of the centre from Allington Knoll will be 61782 feet, which is used in the following computations; because, as a flagstaff of moderate height cannot be easily distinguished among the pinnacles at any considerable distance, it was thought it might be sufficiently accurate for the present purpose, to intersect the steeple itself.

172. *Triangles for determining the Distances of the Stations.*

Stations.	Angles.	Distances.		Feet.
Allington Knoll	61° 37′ 46″	Westwell D. from	Tenterden	58629
Westwell Down	68 0 16		Allington K.	51316
Tenterden	50 21 58			
Allington Knoll	34 37 37	Wye Down	Allington K.	37363
Westwell Down	45 54 19		Westwell D.	29562
Wye Down -	99 28 5 —4			
	180 0 1			
Allington Knoll	96 15 23	Wye Down	Allington	37360
Wye Down -	54 19 24		Tenterden	75603
Tenterden	29 25 13			
Wye Down -	45 8 41			
Westwell Down	113 54 35	Westwell D. from Wye D.		29566
Tenterden	20 56 44			
Allington Knoll	116 49 40	Brabourn D.	Allington K.	26437
Brabourn Down	45 25 31		Tenterden	77397
Tenterden	17 44 49			
Allington Knoll	55 11 54	Brabourn D.	Westwell D.	42233
Brabourn Down	93 52 23		Allington K.	26435
Westwell Down	30 55 43			

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173. *Secondary Triangles.*

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
	° ′ ″		Feet.
Wye Down -	42 20 58	Ashford -	23922
Westwell Down -	53 35 53		20023
Ashford Steeple			
Wye Down -	86 44 28	Brook -	7983
Westwell Down -	15 18 43		30181
Brook Steeple			
Wye Down -	60 6 18	Willesborough	21881
Westwell Down -	45 28 29		26607
Willesborough Steeple			
Wye Down -	58 2 28	Windmill -	19916
Westwell Down -	41 37 0		25443
Willesborough Windwill			
Wye Down -	58 20 46	Kingsnorth -	32498
Westwell Down -	65 40 7		30360
Kingsnorth Steeple			
Wye Down -	52 13 44	Shadoxhurst -	44118
Westwell Down -	85 50 2		34966
Shadoxhurst Steeple			
Wye Down -	26 38 18	Kennington -	16989
Westwell Down -	27 54 54		16271
Kennington Steeple			
Wye Down -	62 23 7	Great Chart -	34029
Allington Knoll -	54 24 4		37083
Great Chart Steeple			
Wye Down -	96 45 26	Westwell -	27384
Allington Knoll -	33 49 30		48851
Westwell Steeple			
Westwell Down -	97 22 43	Pluckley -	20768
Allington Knoll -	20 53 1		57778
Pluckley Steeple			
Westwell Down -	37 55 0	Eastwell -	9168
Allington Knoll -	7 17 0		44441
Eastwell Steeple			

Triangles.		Angles observed.	Distances of the stations from the intersected objects.	
		° ′ ″		Feet.
Westwell Down Allington Knoll *Charing Steeple*	- -	146 22 23 5 24 0	}Charing - {	10211 60085
Westwell Down Allington Knoll *Allington Steeple*	- -	3 15 4 57 34 51	}Allington - {	49609 3333
Brabourn Steeple Allington Knoll *Lymne Steeple*	- -	34 50 49 75 59 12	}Lymne - - {	27443 16161
Brabourn Down Allington Knoll *Mersham Steeple*	- -	33 12 51 45 9 19	}Mersham - {	19136 14784
Brabourn Down Allington Knoll *Monks Horton Steeple*	- -	67 22 25 23 46 14	}Monks Horton {	10657 24405

Operations in 1796, with the small circular Instrument.

174. *Stations.*

Lydd Steeple
Allington Knoll
High Nook
Fairlight Down
Goudhurst Steeple
Tenterden Steeple } Stations in 1787. (near the centre of the roof).

Westwell Down, the station in 1795.

Silver Hill, near Robertsbridge. The station is 22 yards S.W. of the Windmill.

Boughton Malherb Steeple.

175. *Triangles for finding the Distances of the Stations.*

Westwell Down from Tenterden Steeple = 58629 feet, (Art. 172.): this used in the following triangle,

	°	′	″
Boughton Malherb	81	55	9
Westwell Down -	63	44	8
Tenterden - -	34	20	43

gives the distance from Boughton Malherb to Westwell Down 33409 feet. Also, from this last triangle and the next following, (using 54376.5 feet for the distance from Tenterden to Goudhurst, p. 143.),

	°	′	″
Goudhurst -	52	5	44
Boughton Malherb	53	54	20
Tenterden - -	73	59	56

we get 33405 feet for the distance between the same stations: hence the mean, 33407 feet, may be taken for the true distance between Boughton Malherb and Westwell Down. From this latter triangle also, we obtain the distance from Boughton Malherb to Tenterden 53097.2 feet.

Triangles.	Angles.	Distances.	Feet.
Goudhurst - Silver Hill - *Tenterden* -	65° 29′ 7″ 70 32 26 43 58 27	Silver Hill from Goudhurst	40043
Fairlight Down from Tenterden 71637.2 feet, (p. 144.)			
Fairlight Down Silver Hill - *Tenterden* -	46 34 5 82 25 8 51 0 47	Silver Hill from Fairlight D.	56174

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By the two last triangles, we get 52472, and 52481 feet, for the distances of Tenterden from Silver Hill; the mean of which, 52476.5, we shall hereafter use in determining the distances of the objects intersected from those stations.

For the distances of the stations in 1787, made use of in the following triangles, see Art. 57. The point marking the station on Tenterden Steeple in 1787, is considered as being too near the centre to make any reductions necessary for these computations. The greatest uncertainty in any of the distances, on this account, can be only about 3 or 4 feet.

176. During the operation of this year, the instrument was also taken to the following stations, *viz.*

Bidenden Steeple,
Hartridge,
Warehorn Steeple,
Stone Crouch,
Iden Steeple,
Brede Steeple.

To determine the distances between these objects, and the stations from whence they were observed, we have the following triangles.

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
	° ′ ″		Feet.
Goudhurst - -	18 16 4	Bidenden -	41097
Tenterden - -	40 0 12		20040
Bidenden Steeple			
Goudhurst - -	27 21 34	Hartridge -	19134
Tenterden - -	13 14 13		38404
Hartridge			

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Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
Allington Knoll - Lydd - *Stone Crouch*	° ′ ″ 44 16 25 73 7 50	Stone Crouch -	51580 37627
Allington Knoll - Stone Crouch - *Wareborn Steeple*	15 46 51 17 18 22	Warehorn -	28107 25696
Tenterden - - Fairlight Down - *Iden Steeple*	28 55 46 20 42 7	Iden - -	33239 45483
Iden - - - Fairlight Down - *Winchelsea Steeple*	21 57 0 17 5 40	Winchelsea -	21224 26990
Brede Steeple - Fairlight Down - *Winchelsea Steeple*	67 26 0 64 28 0	Brede - -	21755 26373

177. *Secondary Triangles.*

Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
Goudhurst - - Tenterden - - *Ulcomb Steeple*	59 47 4 61 44 12	Ulcomb -	56184 55123
Goudhurst - - Tenterden - - *Sutton Windmill*	65 36 50 52 13 42	Windmill -	48610 56009
Goudhurst - - Tenterden - - *Chart Sutton Steeple*	70 48 44 48 11 12	Chart Sutton -	46338 58717
Goudhurst - - Tenterden - - *Linton Steeple*	91 32 50 36 54 6	Linton - -	41690 69407
Goudhurst - - Tenterden - - *Headcorn Windmill*	49 11 14 47 51 2	Windmill -	40621 41468

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Triangles.	Angles observed.			Distances of the stations from the intersected objects.	Feet.
Goudhurst - -	° 29	′ 8	″ 0	Cranbrook -	18239
Hartridge - -	70	10	0		9439
Cranbrook Steeple					
Tenterden - -	94	50	33	Benenden -	24799
Boughton Malherb	24	7	11		60471
Benenden Steeple					
Bidenden - -	38	47	0	Staplehurst -	25514
Goudhurst - -	37	0	0		26555
Staplehurst Steeple					
Bidenden - -	33	30	0	Marden - -	40015
Goudhurst - -	70	42	33		23399
Marden Steeple					
Boughton Malherb	14	39	40	Frittenden -	36203
Goudhurst - -	17	10	0		31045
Frittenden Steeple					
Tenterden - -	20	46	0	Windmill -	51527
Silver Hill - -	76	45	52		18768
Brasses Windmill					
Tenterden - -	11	2	0	Hawkhurst -	44028
Silver Hill - -	42	17	30		12522
Hawkhurst Steeple					
Silver Hill - -	72	5	37	Sandhurst -	16448
Fairlight Down -	17	1	25		53460
Sandhurst Steeple					
Silver Hill - -	58	27	19	Whittersham -	50861
Fairlight Down -	55	42	10		52469
Whittersham Steeple					
Silver Hill - -	38	49	4	Peasemarsh -	49016
Fairlight Down -	59	39	33		35602
Peasemarsh Steeple					
Silver Hill - -	82	8	4	Rolvenden -	38028
Fairlight Down -	36	28	0		63380
Rolvenden Steeple					

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Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
Silver Hill - - Fairlight Down - *Beckley Steeple*	° ′ ″ 42 30 35 35 36 7	Beckley - -	33419 38790
Allington Knoll - High Nook - - *New Church Steeple*	46 3 7 36 41 43	New Church -	13967 16828
Allington Knoll - High Nook - - *Ivy Church Steeple*	52 3 53 76 5 26	Ivy Church -	28621 23256
Allington Knoll - High Nook - - *St. Mary's Steeple*	27 21 0 80 5 0	St. Mary's -	23939 11165
Tenterden - - Lydd - - *Playden Steeple*	34 33 5 34 35 48	Playden -	40204 40158
Brede Steeple - Fairlight Down - *Icklesham Steeple*	56 0 0 55 1 0	Icklesham -	19094 19321
Stone Crouch - Allington Knoll - *Woodchurch Steeple*	55 9 34 32 59 15	Woodchurch -	28098 42357
Stone Crouch - Allington Knoll - *Old Romney Steeple*	41 36 38 35 59 39	Old Romney -	31037 35070
Stone Crouch - Allington Knoll - *New Romney Steeple*	41 54 7 52 21 33	New Romney -	40957 34544
Stone Crouch - Allington Knoll - *Brookland Steeple*	40 47 1 14 44 21	Brookland -	15919 40872
Stone Crouch - Allington Knoll - *Orleston Steeple*	20 16 5 29 46 58	Orleston -	33421 23308

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Triangles.	Angles observed.			Distances of the stations from the intersected objects.	Feet.
Stone Crouch -	67°	14′	56″	East Guilford -	15782
Lydd - -	24	46	59		34721
East Guilford Steeple					
Stone Crouch -	53	4	1	Snargate -	17900
Lydd - -	28	2	7		30443
Snargate Steeple					
Stone Crouch -	25	37	0	Snave - -	26606
Warehorn Steeple -	81	34	0		11629
Snave Steeple					
Stone Crouch -	9	11	12	Appledore -	11016
Warehorn - -	6	46	0		14925
Appledore Steeple					
Warehorn - -	91	6	0	Brenzet -	16476
Allington Knoll -	30	5	41		32852
Brenzet Steeple					
Allington Knoll -	36	36	26	Bethersden -	49701
Westwell Down -	68	55	44		31762
Bethersden Steeple					
Allington Knoll -	49	12	12	High Halden -	55827
Westwell Down -	70	39	8		44793
High Halden Steeple					
Westwell Down -	17	24	40	Lenham -	30424
Boughton Malherb	64	19	30		10101
Lenham Steeple					
Westwell Down -	12	31	21	Egerton -	24722
Boughton Malherb	30	1	45		10711
Egerton Steeple					
Westwell Down -	42	50	41	Romden Stables	34586
Boughton Malherb	71	6	34		24858
Turret on Romden Stables					
Westwell Down -	37	22	21	Smarden -	39104
Boughton Malherb	84	23	32		23850
Smarden Steeple					

Bearings of the Objects intersected in the Survey with the small circular Instrument, from the Parallels to the Meridian of Greenwich; also their Distances from that Meridian, and its Perpendicular.

178. At Folkstone Turnpike, the bearing of the station on Dover Castle in 1787, from the parallel to the Meridian of Greenwich is 65° 52′ 46″ NE. The new point on the Keep is $6\frac{1}{2}$ feet north-eastward from the old one, which will subtend an angle at Folkstone Turnpike of about 38″; therefore the new station bears 65° 52′ 8″ NE. The bearing of the centre of Tenterden Steeple from Allington Knoll, is nearly the same as that of the station in 1787, or 85° 47′ 25″ SW. See page 153, for the bearings and distances whence those in the three following Articles have been derived. But it may be proper to remark, that some of the bearings (and consequently the distances from the meridian and perpendicular) which depend on Goudhurst and Tenterden, will differ a little when obtained from different routes, because the stations in 1787 were not at the centres of the roofs of the steeples. These variations, however, are of little consequence, as the computed latitudes and longitudes which follow, are generally put down to the nearest *second* only.

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179. *Bearings and Distances of the Stations, 1795.*

Bearings from the Parallels to the Meridian of Greenwich.		Distances from merid.	Distances from perp.
At Folkstone Turnpike.	° ′ ″	Feet.	Feet.
Dover - -	65 52 8 NE	303777	124314
Hawkinge - -	29 45 38 NE	276602	134372
At Dover.			
Paddlesworth -	81 30 42 SW	262001	130549
Waldershare -	36 24 53 NW	290111	105788
Ringswold - -	30 21 52 NE	315780	103826
At Waldershare.			
Shore - -	39 54 35 NE	317542	72993
Mount Pleasant -	11 56 19 NE	302713	46186
Wingham - -	16 36 24 NW	279530	70311
Hardres - -	74 21 9 NW	248177	94042
Hawkinge -	25 17 53 SW		
Ringswold - -	85 37 43 NE		
Near the Shore.			
Ringswold - -	3 16 15 SW		
Mount Pleasant -	28 56 58 NW		
At Mount Pleasant.			
Wingham - -	43 51 31 SW		
Chislet - -	82 23 48 SW	272915	50164
At Wingham.			
Chislet - -	18 10 37 NW		
Hardres - -	52 52 37 SW		
Beverley Park -	77 3 23 NW	247057	62848
At Beverley Park.			
Hardres - -	2 3 23 SE		

Bearings from the Parallels to the Meridian of Greenwich.		Distances from merid.	Distances from perp.
At Allington Knoll.	° ′ ″	Feet.	Feet.
Tenterden - -	85 47 25 SW		
Westwell Down -	32 34 49 NW	192300	100795
Wye Down - -	2 2 48 NE	221267	106699
Brabourn Down -	22 37 5 NE	230100	119634

180. *Interior Objects.*

At Dover.			
St. Radigund's Abbey -	88 5 4 NW	287590	123773
Hougham Steeple -	68 19 22 SW	288338	130451
Gunston Steeple -	3 43 2 NW	303186	115222
St. Margaret's Steeple	51 54 43 NE	315145	115404
South Foreland Light-House - -	70 10 31 NE	315142	120217
At Waldershare.			
Barham Windmill -	61 0 4 NW	268570	93848
Elham Windmill -	10 14 39 SW	284427	137242
Upper Deal Chapel -	63 17 33 NE	317053	92233
Deal Castle - -	66 9 16 NE	321839	91764
Watch-house near the Shore	85 2 37 SE	321311	108494
Sandown Castle -	55 51 56 NE	321718	84361
Walmer Steeple -	73 8 30 NE	318335	97235
Ripple Steeple -	70 1 50 NE	302864	97520
Waldershare Steeple -	64 52 20 NE	295232	103386
Eastry Steeple -	23 30 46 NE	300390	82162
Ash Steeple - -	4 44 29 NE	293066	70161
Minster Steeple -	11 24 56 NE	301152	51109
Woard Steeple -	34 11 33 NE	308964	78038
Sandwich highest Steeple	26 19 14 NE	307184	71275
Wingham Steeple -	20 6 36 NW	278004	72721
Goodneston Steeple -	19 16 21 NW	281912	82339
Littlebourn Steeple -	27 39 59 NW	271797	70856
Canterbury Cathedral -	49 51 48 NW	248195	70446

Bearings from the Parallels to the Meridian of Greenwich.		Distances from merid.	Distances from perp.
At Ringswold.	° ′ ″	Feet.	Feet.
Mongeham Steeple -	21 30 34 NW	311608	93239
Norbourn Steeple -	31 52 45 NW	307620	90706
Woodnesborough Steeple	29 51 29 NW	299690	75796
Near the Shore.			
Ramsgate Windmill -	12 13 37 NE	322348	50813
St. Lawrence Steeple -	7 30 0 NE	320814	48144
At Mount Pleasant.			
Birchington Steeple -	20 17 12 NW	298726	35399
St. Nicholas Steeple -	78 0 9 NW	286388	42717
Stormouth Steeple -	65 26 52 SW	283140	55128
At Wingham.			
The South Reculver -	8 3 15 NW	274343	33659
Hearne Windmill -	34 59 11 NW	260188	42675
Blean Steeple -	76 41 11 NW	241258	61255
Wickham Steeple -	77 21 44 NW	270920	68380
Bridge Windmill -	55 21 3 SW	260129	83719
Nackington Steeple -	69 29 17 SW	249851	81414
Chillendon Windmill -	28 0 30 SE	286588	83582
Preston Steeple -	5 6 13 NW	278888	63120
Shottenden Windmill -	83 42 1 SW	212203	77744
Ickham Steeple -	89 45 57 SW	271530	70344
At Hardres.			
Harbledown Steeple -	14 15 0 NW	241952	69531
Sturry Steeple -	15 26 36 NE	256616	63495
West Stone-street Windmill	35 46 24 SW	236867	109739
Stelling Windmill -	26 1 10 SW	242000	106696
On Westwell Down.			
Ashford Steeple -	24 53 15 SE	200726	118959
Brook Steeple -	63 10 25 SE	219232	114415
Willesborough Steeple -	33 0 39 SE	06795	123107
Kingsnorth Steeple -	12 49 1 SE	99035	130398

Bearings from the Parallels to the Meridian of Greenwich.		Distances from merid.	Distances from perp.
On Westwell Down.	° ′ ″	Feet.	Feet.
Shadoxhurst Steeple -	7 20 54 SW	187828	135474
Kennington Steeple -	50 34 14 SE	204867	111129
At Allington Knoll.			
Great Chart Steeple -	52 21 16 NW	190570	121387
Westwell Steeple - -	31 46 42 NW	194206	102508
Pluckley Steeple - -	53 27 50 NW	173509	109639
Eastwell Steeple -	25 17 49 NW	200943	103856
Charing Steeple -	37 58 49 NW	182956	96675
Allington Steeple -	25 0 2 NE	221342	141015
Lymne Steeple -	81 23 44 SE	235912	146454
Mersham Steeple - -	22 32 14 NW	214267	130381
Monk's-Horton Steeple	46 23 19 NE	237603	127202

181. *Bearings and Distances of the Stations, and Interior Objects, intersected in 1796.*

At Goudburst.			
Boughton Malherb -	54 59 23 NE	159327	95484
Bidenden - -	88 49 3 NE	147434	131748
Hartridge - -	79 43 33 NE		
At Fairlight Down.			
Silver Hill - -	34 28 24 NW		
Iden Steeple - -	32 47 48 NE	167948	180385
Brede Steeple -	14 34 32 NW	137837	197564
At Allington Knoll.			
Stone Crouch - -	57 3 23 SW	176646	172086
Warehorn Steeple -	72 50 14 SW	193078	152330

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Interior Objects.

Bearings from the Parallels to the Meridian of Greenwich.					Distances from merid.	Distances from perp.
At Goudhurst.	°	′	″		Feet.	Feet.
Frittenden Steeple -	72	9	23	NE	135897	123083
Linton Steeple - -	15	32	17	NE	117513	92429
Chart Sutton Steeple -	36	16	23	NE	133760	95238
Sutton Windmill -	41	28	17	NE	138537	96172
Ulcomb Steeple -	47	18	3	NE	147636	94495
Headcorn Windmill -	57	53	53	NE	140755	111009
Staplehurst - -	51	49	3	NE	127219	116180
Cranbrook Steeple -	71	8	27	SE	123605	138492
At Fairlight Down.						
Rolvenden Steeple -	1	59	36	NE	145517	155277
Beckley Steeple - -	1	7	43	NE	144076	179836
Peasemarsh Steeple -	25	11	9	NE	158462	186401
Whittersham Steeple -	21	13	46	NE	162311	169710
Sandhurst Steeple - -	17	26	59	NW	127281	167618
Winchelsea Steeple -	49	53	28	NE	163954	201230
Icklesham Steeple -	40	26	28	NE	155845	203913
At Allington Knoll.						
Bethersden - -	69	11	15	NW	173476	126377
High Halden - -	81	47	1	NW	164679	136058
Orleston Steeple -	86	50	21	SW	196661	145321
Woodchurch Steeple -	89	57	22	NW	177576	144004
Brookland Steeple -	42	19	2	SW	192417	174257
Old Romney Steeple -	21	3	44	SW	207329	176763
New Romney Steeple -	4	41	50	SW	217104	178464
Brenzet - - -	42	44	33	SW	197637	168163
At Boughton Malherb.						
Benenden Steeple - -	25	12	14	SW	133576	150198
At Silver Hill.						
Brasses Windmill - -	40	7	40	SE	123612	186658

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Bearings from the Parallels to the Meridian of Greenwich.		Distances from merid.	Distances from perp.
At High Nook.	° ′ ″	Feet.	Feet.
New Church Steeple -	57 43 31 NW	214025	156692
Ivy Church Steeple -	82 52 46 SW	205177	168561
St. Mary's Steeple -	78 53 12 SW	217297	167830
At Lydd.			
Playden Steeple -	85 3 0 NW	169337	187236
At Westwell.			
Lenham Steeple -	63 25 45 NW	165089	87186
Egerton Steeple - -	86 38 14 SW	167621	102245
Smarden Steeple -	61 47 14 SW	157842	119281
Turret on Romden Stables	56 18 54 SW	163521	119978
At Stone Crouch.			
Appledore Steeple -	30 33 49 NE	182247	162601
Snave Steeple - -	65 22 1 NE	200830	160997
Snargate Steeple - -	66 35 7 NE	193072	164973
East Guilford Steeple	6 54 4 SW	174750	187754

182. *Latitudes and Longitudes of Objects intersected in 1795.*

Names of objects.	Latitude.	Longitude east from Greenwich. In degrees.	In time.
	° ′ ″	° ′ ″	m. s.
The Belvidere in Waldershare Park	51 10 53	1 15 39	5 2.6
Ringswold, or Kingswould Steeple	51 11 8	1 22 20	5 29.3
Upper Hardres Steeple - -	51 13 1	1 4 45	4 19
Chislet Steeple - -	51 20 4	1 11 24	4 45.6
St. Radigund's Abbey - -	51 7 56	1 14 44	4 58.9
Hougham Steeple - -	51 6 50	1 15 4	5 0.3
Gunston Steeple - - -	51 9 18	1 19 0	5 16
St. Margaret's Steeple - -	51 9 14	1 22 7	5 28.5
South Foreland Light-House -	51 8 26	1 22 6	5 28.4
Barham Windmill - -	51 12 54	1 10 5	4 40.3

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Names of Objects.	Latitude.			Longitude east from Greenwich. In degrees.			In time.	
	°	'	"	°	'	"	m.	s.
Elham Windmill - -	51	5	44	1	14	1	4	56.1
Upper Deal Chapel - -	51	13	2	1	22	44	5	30.9
Deal Castle - -	51	13	5	1	23	59	5	35.9
Watch-house near the sea shore	51	10	21	1	23	46	5	35.1
Sandown Castle - -	51	14	18	1	23	59	5	35.9
Walmer Steeple - -	51	15	29	1	23	8	5	32.5
Ripple Steeple - -	51	12	12	1	19	0	5	16
Waldershare Steeple - -	51	11	15	1	16	59	5	7.9
Eastry Steeple - -	51	14	44	1	18	26	5	13.7
Ash Steeple - - -	51	16	44	1	16	34	5	6.3
Minster Steeple - -	51	19	50	1	18	46	5	15.1
Woard Steeple - -	51	15	23	1	20	41	5	22.7
Sandwich highest Steeple -	51	16	30	1	20	15	5	21
Wingham Steeple - -	51	16	21	1	12	38	4	50.5
Goodneston Steeple - -	51	14	45	1	13	36	4	54.4
Littlebourn Steeple - -	51	16	40	1	11	1	4	44.1
Canterbury Cathedral -	51	16	48	1	4	51	4	19.4
Mongeham Steeple - -	51	12	53	1	21	18	5	25.2
Norbourn, or Northbourn Steeple	51	13	18	1	20	17	5	21.1
Woodnessborough, or Woodnesborough Steeple - - -	51	15	47	1	18	17	5	13.1
Ramsgate Windmill - -	51	19	49	1	24	20	5	37.3
St. Lawrence Steeple - -	51	20	16	1	23	56	5	43.7
Birchington Steeple - -	51	22	25	1	18	13	5	12.9
St. Nicholas Steeple - -	51	21	15	1	14	57	4	59.8
Stourmouth, or Stormouth Steeple	51	19	13	1	14	3	4	56.2
The South Reculver - -	51	22	47	1	11	50	4	47.3
Hearne Windmill - -	51	21	20	1	8	6	4	32.4
Blean Steeple - -	51	18	19	1	3	4	4	12.3
Wickham Steeple - -	51	17	5	1	10	48	4	43.2
Ickham Steeple - -	51	16	45	1	10	57	4	43.8
Bridge Windmill - -	51	14	35	1	7	55	4	31.7
Nackington Steeple - -	51	14	59	1	5	14	4	20.9
Chillendon Windmill -	51	14	32	1	14	49	4	59.3
Preston Steeple - -	51	17	55	1	12	54	4	51.6
Shottenden Windmill -	51	15	41	0	55	25	3	41.7

Names of Objects.	Latitude.			Longitude east from Greenwich. In degrees.			In time.	
	°	′	″	°	′	″	m.	s.
Harbledown Steeple - -	51	16	58	1	3	13	4	12.9
Sturry Steeple - -	51	17	55	1	7	5	4	28.3
West-Stone-street Windmill -	51	10	22	1	1	45	4	7
Stelling Windmill - -	51	10	51	1	3	6	4	12.4
Ashford Steeple - -	51	8	56	0	52	18	3	29.2
Brook Steeple - -	51	9	38	0	57	8	3	48.5
Willesborough Steeple -	51	8	14	0	53	52	3	35.5
Kingsnorth Steeple - -	51	7	3	0	51	49	3	27.3
Shadoxhurst Steeple - -	51	6	14	0	48	53	3	15.5
Kennington Steeple - -	51	10	12	0	53	24	3	33.6
Great Chart Steeple - -	51	8	33	0	49	39	3	18.6
Westwell Steeple - -	51	11	39	0	50	39	3	22.6
Pluckley Steeple - -	51	10	30	0	45	14	3	0.9
Eastwell Steeple - -	51	11	24	0	52	24	3	29.6
Charing Steeple - -	51	12	37	0	47	44	3	10.9
Allington, or Aldington Steeple	51	5	16	0	57	36	3	50.4
Lymne Steeple - -	51	4	20	1	1	22	4	5.5
Mersham Steeple - -	51	7	1	0	55	47	3	43.1
Monks Horton Steeple -	51	7	30	1	1	53	4	7.5

183. *Latitudes and Longitudes of Objects intersected in 1796.*

Linton Steeple - -	51	13	24	0	30	40	2	2.7
Sutton Windmill - -	51	12	46	0	36	9	2	24.6
Chart Sutton Steeple -	51	12	56	0	34	54	2	19.6
Lenham Steeple - -	51	14	13	0	43	6	2	52.4
Romden Stables - -	51	8	49	0	42	36	2	50.4
Smarden Steeple - -	51	8	57	0	41	8	2	44.5
Bethersden Steeple - -	51	7	45	0	45	10	3	0.7
Rolvenden Steeple - -	51	3	3	0	37	50	2	31.3
Beckley Steeple - -	50	59	1	0	37	24	2	29.6
Bidenden Steeple - -	51	6	55	0	38	23	2	33.5
Headcorn Windmill -	51	10	21	0	36	41	2	26.7
Ulcomb Steeple - -	51	13	1	0	38	31	2	33
Staplehurst Steeple - -	51	9	30	0	33	9	2	12.6

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Names of Objects.	Latitude.	Longitude east from Greenwich. In degrees.	In time.
	° ′ ″	° ′ ″	m. s.
Cranbrook Steeple	51 5 50	0 32 10	2 8.7
Egerton Steeple	51 11 44	0 43 43	2 54.9
Frittenden Steeple	51 8 20	0 35 24	2 21.6
Snargate Steeple	51 1 23	0 50 10	3 20.7
Snave Steeple	51 2 1	0 52 12	3 28.8
Warehorn Steeple	51 3 27	0 50 13	3 20.9
Orleston Steeple	51 4 36	0 51 10	3 24.7
Winchelsea Steeple	50 55 28	0 42 31	2 50
Sandhurst Steeple	51 1 3	0 33 4	2 12.3
Whittersham Steeple	51 0 39	0 42 10	2 48 7
New Church Steeple	51 2 42	0 55 38	3 42.5
Ivy Church Steeple	51 0 45	0 53 18	3 33.2
St. Mary's Steeple	51 0 52	0 56 28	3 45.9
East Guilford Steeple	50 57 40	0 45 21	3 1.4
Appledore Steeple	51 1 47	0 47 22	3 9.5
Old Romney Steeple	50 59 25	0 53 50	3 35.3
New Romney Steeple	50 59 7	0 56 22	3 45.5
Playden Steeple	50 57 46	0 43 56	2 55.7
Brookland Steeple	50 59 51	0 49 58	3 19.9
Iden Steeple	50 58 54	0 43 36	2 54.4
Brede Steeple	50 56 7	0 35 45	2 23
Benenden Steeple	51 3 54	0 34 44	2 18.9
Brasses Windmill	50 57 55	0 32 5	2 8.3
Icklesham Steeple	50 55 3	0 40 24	2 41.6
Boughton Malherb Steeple	51 12 51	0 41 34	2 46.3
Peasemarsh Steeple	50 57 54	0 41 7	2 44.5
Woodchurch Steeple	51 4 51	0 46 12	3 4.8
High Halden Steeple	51 6 11	0 42 52	2 51.5
Brenzet Steeple	50 0 51	0 51 21	3 25.4

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GENERAL VIEW of the ZENITH SECTOR.

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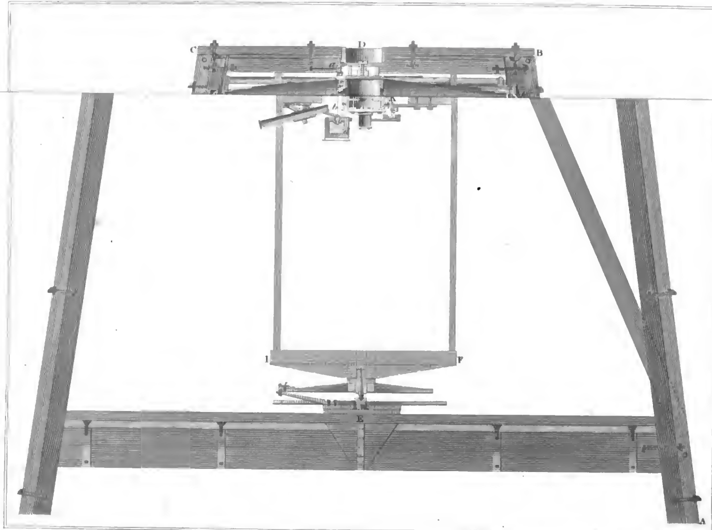
SECTION of the ZENITH SECTOR through the Plane of its AXIS.



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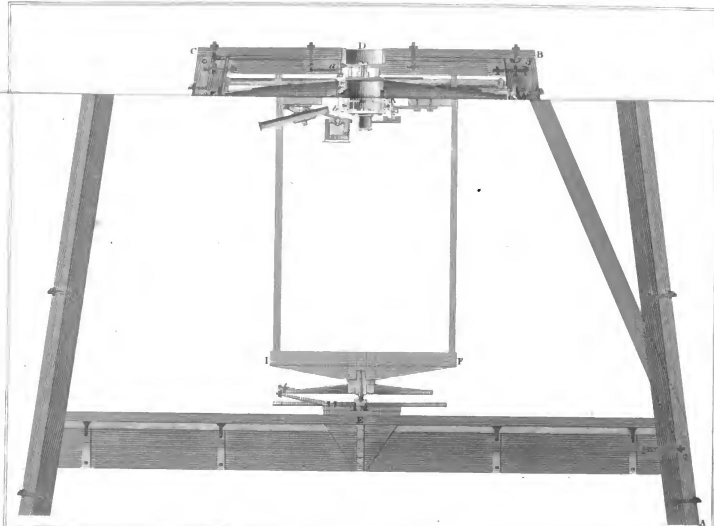
SECTION of the ZENITH SECTOR through the Plane of its AXIS.



Basire sc.

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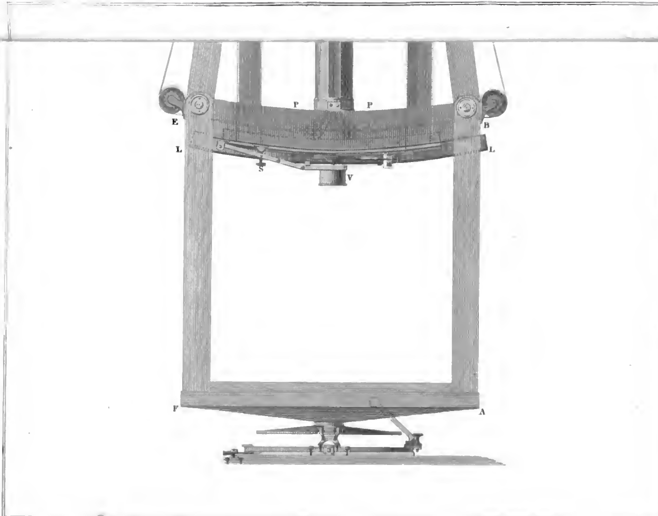
ELEVATION *of the Side of the Interior* ***FRAME*** *carrying the* ZENITH SECTOR.



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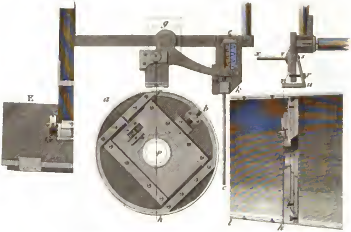
Section of the Diaphragm Carrying the Dot

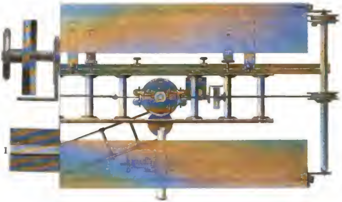
Sectior also a Section of the Axis with the Diaphragm.



Horizon

carrying the

zontal View of the Axles, Pulleys and Arches.



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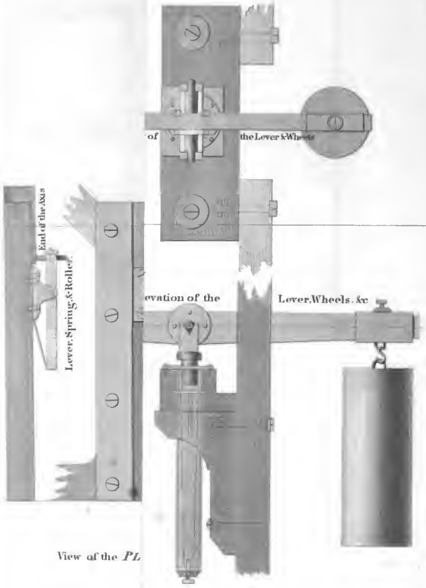
of
the Lever & Wheels
End of the Axis
Lever, Spring, & Roller
evation of the
Lever, Wheels, &c
View of the PL

Philos. Trans. MDCCCIII. Plate XV. p. 508.

TRIANGLES for ascertaining the Meridional Distance between CLIFTON and DUNNOSE.

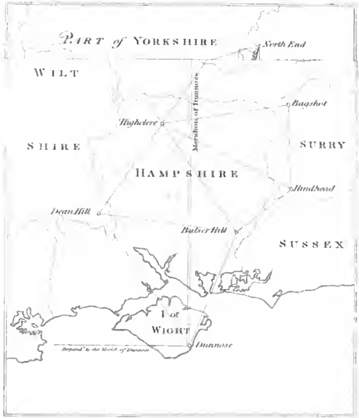

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Fig. 1.

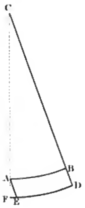
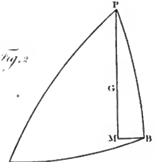


Fig. 2.



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